List of Agents in India from whom Government of India Publications are available.

(a) Provincial Government Book Depots.

Madras :—Superintendent, Government Press, Mount Road, Madras.

Bombay :—Superintendent, Government Printing and Stationery, Queen's Road, Bombay.

Sind :—Manager, Sind Government Book Depôt and Record Office, Karachi (Sadar).

United Provinces :—Superintendent, Government Press, Allahabad.

Punjab :—Superintendent, Government Printing, Punjab, Lahore.

Central Provinces :—Superintendent, Government Printing, Central Provinces, Nagpur.

Assam :—Superintendent, Assam Secretariat Press, Shillong.

Bihar :—Superintendent, Government Printing, P. O. Gulzarbagh, Patna.

North-West Frontier Province :—Manager, Government Printing and Stationery, Peshawar.

Orissa :—Press Officer, Secretariat, Cuttack.

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Advani Brothers, P. O. Box 100, Cawnpore.
Aero Stores, Karachi.*
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Bengal Flying Club, Dum Dum Cantt.*
Bhawnani & Sons, New Delhi.
Bhatia Book Depot, Sadar Bazar, Ranikhett.
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Booklover's Resort, Taikad, Trivandrum, South India.
Burma Book Club, Ltd., Rangoon.
Butterworth & Co. (India), Ltd., Calcutta.
Chatterjee & Co., 3, Bacharam Chatterjee Lane, Calcutta.
Chuckervertty, Chatterjee & Co., Ltd., 15, College Square, Calcutta.
City Book Club, 98, Phayre Street, Rangoon.
Das Gupta & Co., 54/3, College Street, Calcutta.
Delhi and U. P. Flying Club, Ltd., Delhi.*
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English Book Depot, Taj Road, Agra.
English Bookstall, Karachi.
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Faqir Chand Marwah, Peshawar Cantt.
Fono Book Agency, Simla.
Gautama Brothers & Co., Ltd., Meston Road, Cawnpore.
[illegible]
[illegible] Balaram De Street, Calcutta.
Hyderabad Book Depôt, Chaderghat, Hyderabad (Deccan).
Imperial Book Depôt and Press, near Jama Masjid (Machhliwalan), Delhi.
Indian Army Book Depôt, Dayalbagh, Agra.
Indian Book Shop, Benares City.
Indian School Supply Depôt, Central Avenue South, P. O. Dharamtala, Calcutta.
Insurance Publicity Co., Ltd., Lahore.
International Book Service, Poona 4.
Jacques & Co., Kamptee Road, Nagpur, Messrs. Neston.
Jaina & Bros., Mori Gate, Delhi, and Connaught Place, New Delhi, Messrs. J. M.
Kamala Book Depôt, 15, College Square, Calcutta.
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Keale & Co., Karachi.
Keshao Book Stall. Khadi Bazar, Belgaum.
Kitabistan, 17-A, City Road, Allahabad.
Krishnaswami & Co., Teppakulam P. O., Trichinopoly Fort, Messrs. S.
Lahiri & Co., Calcutta, Messrs. S. K.
Local Self-Govt. Institute, Bombay.
London Book Co. (India), Arbab Road, Peshawar, Murree, Nowshera, Rawalpindi.
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Mathur, B. S., Bookseller, Civil Lines, Jodhpur.
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Mohanldl Dossabhai Shah, Rajkot.
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New Book Co., "Kitab Mahal", 192, Hornby Road, Bombay.
Newman & Co., Ltd., Calcutta, Messrs. W.
Oxford Book and Stationery Company, Delhi, Lahore, Simla, Meerut and Calcutta.
Parikh & Co., Baroda, Messrs. B.
Pioneer Book Supply Co., 20, Shib Narayan Das Lane, Calcutta and 219, Cloth Market, Delhi.
Popular Book Depôt, Grant Road, Bombay.
Punjab Religious Book Society, Lahore.
Raghunath Prasad & Sons, Patna City.
Rama Krishna & Sons, Booksellers, Anarkali, Lahore.
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Ray & Sons, 43, K. & L. Edwardes Road, Rawalpindi, Murree and Peshawar, Messrs. J.
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Sharada Mandir, Ltd., Nai Sarak, Delhi.
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Standard Bookstall, Quetta.
Standard Book Depôt, Lahore, Dalhousie and Delhi.
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Tara & Sons, Razmak (India), Messrs. B. S.
Taraporevala Sons & Co., Bombay, Messrs. D. B.
Thacker & Co., Ltd., Bombay.
Thacker, Spink & Co., Ltd., Calcutta and Simla.
Tripathi & Co., Booksellers, Princes Street, Kalbadevi Road, Bombay, Messrs. N. M.
University Book Agency, Kacheri Road, Lahore.
Upper India Publishing House, Ltd., Literature Palace, Ammuddaula Park, Lucknow.
Varadachary & Co., Madras, Messrs. P.
Venkatasubban, A., Law Bookseller, Vellore.
Wheeler & Co., Allahabad, Calcutta and Bombay, Messrs. A. H.
Young Man & Co., Egerton Road, Delhi.

*Agent for publications on Aviation only.

INTRODUCTORY NOTE.

The present Report is divided into three parts. Parts I and II consist of detailed statements of the present position and needs of the dairy and cattle industries. Although my terms of reference were largely concerned with questions relating to the future development of research and education, I found in practice that these could not be answered until the whole field of dairying and of cattle breeding and management had been surveyed. This has, however, given me an opportunity of referring to a number of special problems which require investigation, and of indicating the lines along which future developments might be planned. The more general recommendations of the Report have for convenience been grouped together in Part III. Since the dissemination of scientific and technical information was included in my terms of reference, I have made a number of recommendations in connexion with the provincial advisory services, the subjects dealt with including such questions as the control of cattle improvement and the co-ordination of the work of the central and the provincial governments.

Throughout my survey I have been given ample opportunity of investigating the various subjects which fall within my terms of reference. I desire to express my indebtedness to all those who facilitated my work by their willing co-operation and their generous hospitality during my tour. In particular I should mention the various Directors of Agriculture and of Veterinary Services and the Provincial Live Stock Experts, who were responsible for local arrangements and who were at all times most willing to give me the benefit of their knowledge and experience. The general arrangements for my visit were made by the Imperial Council of Agricultural Research. I gratefully acknowledge the assistance given to me by Sir Bryce Burt, the Vice-Chairman, by Sir Arthur Olver, the Animal Husbandry Expert, and by other officials of the Council. I am also indebted to Mr. Z. R. Kothavalla, Imperial Dairy Expert, who accompanied me on a part of my tour and who was able to give me much useful information regarding the present state of the Indian dairy industry. My thanks are also due to Mr. A. M. Livingstone,

CHAPTER I—The need for an increased consumption of milk.

The total output of milk in India is exceptionally large One authority has placed the annual production at over 1,000 million maunds(1) A more recent survey(2) indicates that this is likely to be an over estimate, and that the figure lies nearer 700 million maunds The latter figure would, however, represent the hand milked yield, and would need to be increased by at least 15 per cent (say, to 800 million maunds), to give the gross output of milk The monetary value of this output is shown later to approximate 300 crores of rupees Compared with other countries, India stands second in volume of milk production her output being exceeded only by the United States of America She produces over four times the output of Great Britain, over five times that of Denmark, over six times that of Australia, and over seven times that of New Zealand

India's milk production.

The production of milk cannot however be considered without reference to the needs of the population who have to subsist on it It is here that India falls to the lowest place among those countries for which statistics are available* This point is shown clearly in Table 1 The total production of milk is given in the first column the human population in the second column, and the calculated production per head of population in the third column This column provides, therefore, a measure of the adequacy of milk production in terms of the requirements of the population

It will be seen that the countries may be classed into three groups Six countries show productions of between 30 and 40 oz per head per day In these countries the production per head agrees closely with the estimated consumption which is shown in the fourth column and which may probably be taken as adequate for the nutritional needs of the population Such countries are self supporting in so far as their milk requirements are concerned Nine countries show productions in excess of 40 oz per head per day *These are countries such as* Australia, Canada, *New Zealand and* the Scandinavian nations, which have an exportable surplus of milk The remaining five countries show productions below 30 oz per head per day These countries do not produce enough milk to supply their own requirements, and must either import milk products or subsist on a diet deficient in milk A highly industrialised nation like Great Britain is able to import sufficient milk products to raise the consumption to an adequate level(3) On the other hand countries which are predominantly rural, such as Poland, Italy,

(1) A Olver and M Vaidyanathan, "Assessment of the Annual Contribution of Live Stock to Indian Economy"

(2) Results of Provincial Marketing Surveys

*Unfortunately no similar information is available for tropical or far eastern countries

(3) It may be noted however, that 60 per cent of Great Britain's consumption is in the form of butter, a very incomplete food The milk equivalent of the whole milk products consumed would only be about 16 oz per head per day

Roumania and India, cannot afford to import milk products, and their populations are therefore unable to obtain an adequate supply of milk to meet their nutritional needs. Thus it will be seen that India's consumption of 7 to 8 oz. per head per day is less than a quarter of that of the self-supporting countries.

Present per capita consumption.

It may be asked whether the estimate of 7 to 8 oz. is a true indication of the daily *per capita* consumption, since it is based on very rough estimates of the average milk yields and lactation periods of Indian cattle. An alternative method of determining the level of milk consumption is by dietary surveys, though these are also subject to considerable error—partly because information collected from consumers is frequently unreliable (especially in dealing with a relatively uneducated population) and partly because dietary surveys necessarily apply to a very restricted section of the population. Unfortunately few such surveys have been carried out in India, but it will be well to see how far the available figures agree with the estimate already mentioned. In a survey of the food consumption of tenant cultivators in Western Punjab(4) details of milk consumption are available for 39 families. The average daily *per capita* consumption was found to be 5 oz., but in addition 0.6 oz. of *ghee* was taken. As the survey related to the families of cultivators it may be assumed that the *lassi* (butter-milk), which is left as a by-product of the manufacture of *ghee* and is a most popular beverage, was also included in the diet. The total milk equivalent would thus be raised to just over 14 oz. per head per day. The Report mentions, however, that milk consumption depended on wealth as well as age, and that " the menials use little milk other than *lassi*...... The poorer non-agriculturists cannot afford to take *ghee* or milk even occasionally, except on festive days ". Similar figures have been obtained in a recent investigation in the Sialkot District of the Punjab(5), where the milk consumption of 60 families averaged between 5 and 5½ oz., and the total milk equivalent consumed (*i.e.*, including curds and *ghee*) was between 16 and 18 oz. per head per day. On the other hand very different results have been recorded in a dietary survey carried out in South Indian villages(6). In this survey milk and milk products were found to be entirely absent from the diets of 31 out of the 44 families investigated, while the average milk consumption of the remaining 13 families was less than 3 oz. per day. This was supplemented by curds and *ghee* equivalent to a little over 4 oz. of milk, giving a milk equivalent consumption of barely 7 oz. per head daily. Spread over the 41 families, this average figure would be reduced to only 2 oz. per head per day. It has long been recognised that differences in the consumption of milk and milk products are probably associated with the marked

(4) S. Lal and W. Roberts. " Rates of Food Consumption by 71 families of Tenant Cultivators in the Khanewal Tahsil, Multan District ". Punjab Board of Economic Inquiry Publication No. 29, 1935.

(5) N. C. Wilson. Unpublished data.

(6) W. R. Aykroyd and B. G. Krishnan. " Diet Surveys in South Indian Villages ". *Indian Journ. Med. Res.* 24, 667 (1937).

differences in physical development of the northern and southern races of India Such differences in milk consumption have been noted by Sir John Megaw[7] and are also apparent in the estimates of milk production made in the recent provincial marketing surveys (see Table 2)

It is also found that the consumption of milk and milk products is markedly lower in urban than in rural areas An inquiry conducted in nearly 2,500 working class households in Bombay[8] showed that the average quantity of milk consumed per head per day was less than half an ounce This was supplemented by 0 05 oz of *ghee* A similar inquiry among 97 families of jute mill workers in Bengal[9] gave a *per capita* daily consumption of just under one ounce of milk and of 0 10 oz of *ghee* These figures refer, however, to selected groups of the population Table 3 shows the collected figures for a number of typical municipalities[10] It will be seen that the consumption in these municipalities is generally lower than the corresponding provincial estimate as given in Table 2 It is, moreover, probably true that little or no *lassi* (butter milk) is consumed in towns unless this is specially made from curds butter milk itself is essentially a rural product

In view of the wide variations in milk consumption which are found between rural and urban populations and between the populations of Northern and Southern India, it is obviously impossible to arrive at an average consumption figure from dietary surveys The figures quoted are, however sufficient to indicate that a *per capita* daily consumption of 7 to 8 oz of milk (either in liquid form or as milk products) is not an unreasonable estimate for India as a whole

Dietary Requirements

The next step is to determine to what extent this daily *per capita* consumption ought to be increased in order to meet the minimum requirements of the population European standards are only of limited value in this connection, for they are based on the assumption that the population lives on a mixed diet which includes meat and other sources of animal protein Moreover such standards are based on the needs of the body in temperate zones In India the climate is sub tropical or tropical, and most of the population subsists on a vegetarian diet derived from a very limited variety of foodstuffs Milk is, in fact, frequently the only available source of 'first class' protein, while it also has to supply a considerable proportion of the mineral constituents and vitamins of the diet

In view of the special importance of milk as the sole source of 'first class' protein, the quantity needed in the average Indian

(7) Figures quoted from brief

(8) G Findlay Shirras "Report on an Enquiry into Working Class Budgets in Bombay" Government Central Press, 1923

(9) A C Roy Choudhury "Report on an Enquiry into the Standard of Living of Jute Mill Workers in Bengal." Bengal Secretariat Book Depot 1930

(10) Figures obtained directly from municipalities

dietary can best be calculated on a basis of protein requirement. According to European standards, about 10 to 15 per cent. of the daily intake of energy should be derived from protein. For an average man this would entail an intake of about 100 grams of protein per day. Of this, roughly one-third (say, 37 grams) should be 'first-class' protein(11). A recent Indian publication(12) puts the requirement somewhat lower, namely, 65 grams of total protein, of which about one-quarter should be of animal origin. Using these two standards as a basis for calculation of the milk requirement, the following figures are obtained :—

	European Standard.	Indian Standard.
Daily requirement of 'first-class' protein per head.	37 grams.	16 grams.
Amout of milk needed to supply this quantity of protein, say.	1,000 grams.	430 grams.
or a daily intake of	35 oz.	15 oz.

It will be seen that the standard European requirement coincides closely with the actual consumption in the self-supporting countries shown in Table 1. Although the standard Indian requirement is very much smaller, *it is still double the quantity of milk at present available in the country,* namely 7 to 8 oz. per head. Moreover, the Indian requirement is based on an admittedly low standard. "This scale" it is stated "falls short of the ideal as defined by modern physiologists and may often with advantage be exceeded. It is nevertheless excessive, as far as India is concerned, *in the sense that economic circumstances and dietary habits often prevent its attainment.*" It would appear from this statement that the scale has, indeed, been somewhat arbitrarily fixed at a low figure in order to make it a feasible standard under Indian conditions. If the standard were to be set at a level more nearly akin to that aimed at in progressive European countries, the present output of milk in India would not merely need to be doubled, but would have to be increased three-fold or even four-fold.

It is significant that this general conclusion has been arrived at independently by another method of computation. In the article referred to(13) an attempt was made to estimate the adequacy of India's net food supply for the nutrition of her population. It was found that whereas the total energy available was adequate and the amount of carbohydrate was actually in excess, the quantities of fat and of 'first-class' protein were markedly deficient. "Clearly" the author writes "the most important task confronting the social reformer who seeks to make India's food supply satisfy decent standards of nutrition is to increase milk production in India......

(11) "The Criticism and Improvement of Diets." Memorandum by the Advisory Committee of the Ministry of Health, 1934.

(12) W. R. Aykroyd. "The Nutritive Value of Indian Foods and the Planning of Satisfactory Diets." Health Bulletin No. 23. Govt. of India Press, 1937.

(13) "India's Food Problem." The Economist, 26th December 1936.

A doubling of India's milk supply will not only increase the quantity of first class protein available per head, but will also increase the element of animal fat in the Indian diet, which at present is largely supplied by vegetable oil "

While the argument for increasing milk consumption has so far been based on the requirement of 'first-class' protein, the value of milk as a 'protective' food must not be lost sight of With a vegetarian diet derived from a very limited variety of foodstuffs, there is a serious risk of a deficiency of both minerals and vitamins An increase in the consumption of milk would go far towards correcting the present deficiency of protective elements in Indian dietaries, particularly in so far as growing children are concerned

Results of milk feeding experiments.

The value of increasing the consumption of milk is well illustrated in the results obtained in two series of experiments in which the diet of children of school age was supplemented with a ration of milk Two reports have been issued in connection with a scheme sponsored by the municipality of Simla(14) This scheme was designed to ascertain the effect of adding a supplement of 1 lb of whole milk per day to the ordinary diet of children for a period of three months The total number of children covered in the first report was 44 and in the second report 112 The weights and heights of the children, as well as of similar (control) groups who received no milk supplement, were taken at the beginning and at the end of the feeding period The results are shown in Table 4 It will be seen that the children receiving milk showed markedly greater increases in both weight and height over those who received no milk supplement

A somewhat similar experiment has been carried out among residential institutions for children in South India(15) In this experiment, however, it was not possible on account of expense to give the children whole milk and they were therefore given a supplement of skim milk reconstituted from milk powder Moreover, the quantity fed was limited to 1 to 1½ oz of skim milk powder, equivalent to roughly 8 oz of liquid skim milk The results are shown in Table 5 At the end of three months feeding children receiving the milk supplement showed a marked increase in weight and height over those receiving no milk supplement Moreover, the same children were later used in an identical experiment, but in this case the groups were reversed, those who had previously acted as controls receiving the milk supplement The results again showed the value of the supplement of skim milk to those children who received it It is, moreover, significant that in this experiment the addition of the supplement of milk was found to reduce the incidence of two pathological conditions, i e, stomatitis and phrynoderma,

(14) W H Crichton "First and Second Reports of the Milk Scheme sanctioned by the Simla Municipality "

(15) W R Aykroyd and B G Krishnan. "The Effect of Skimmed milk, Soya Bean and other Foods in Supplementing Typical Indian Diets" *Ind Journ Med Res* 24, 4 (1937)

both of which are now recognised to be nutritional deficiency diseases which can be prevented by the presence of 'protective' foods in the diet.

Relation to income level.

These results, together with the known deficiency of milk in the average Indian diet, are sufficient to indicate the very great need for increasing the milk consumption of the country. The question arises, however, as to whether, if the necessary increase in production is effected, the population could afford to purchase the additional milk. There is no doubt that the Indian appreciates the value of milk, and that if he has sufficient means he will increase his consumption of this food. The *per capita* consumption depends, however, very largely on income level. Table 6 shows the average family expenditure on milk and *ghee* in comparison with the total food expenditure in three urban centres[16]. The proportion spent on these two milk products (5 to 15 per cent.) is very low in comparison with that suggested in other countries[17], but it is significant to find that this proportion rises markedly with increasing income. Table 7 shows, for example, the quantities of milk and *ghee* consumed by Bombay families at various income levels, and the relation of expenditure on these products to total food expenditure. The consumption of milk shows a ten to fifteen-fold increase, and the consumption of *ghee* a seven-fold increase, between the lowest and the highest income groups. At the same time the proportion of the total food expenditure used for the purchase of milk products rises from 3 per cent. to 11 per cent. Similar results have been obtained in a survey undertaken at Lahore[18]. The differences in income level were, however, very much greater in this survey. Table 8 shows that the milk consumed increased with income level until, with incomes of Rs. 1,000 per month and over, a maximum figure of 30 oz. per head per day was reached[19]. On the other hand at income levels below Rs. 100 per month the consumption of milk was comparatively low, while in the lowest income group it was less than 3 oz. daily. The average *per capita* income in India is about Rs. 100 per year[20]. It is therefore difficult to see how milk consumption can be increased among the poorer classes unless the price of milk is lowered or the income level is raised. This point is specially referred to in a recent publication which deals with the

(16) See Reports on Enquiries into Working Class Family Budgets in Bombay (1922), Ahmedabad (1924) and Bombay City (1932), and into Family Budgets of Cotton Mill Workers in Sholapur City (1925). (Govt. Central Press, Bombay).

(17) See, for example, the Report of the Committee on Nutrition of the British Medical Association (1933) where the proportion of food expenditure allocated to milk and milk products lies between 20 and 35 per cent.

(18) R. Lal Anand and A. C. Aggarwala. "The Milk Supply of Lahore in 1930." Punjab Board of Economic Inquiry, Publication No. 28, 1935.

(19) It is significant that this corresponds closely with the average milk consumption of the self-supporting dairying countries shown in Table 1. It would seem that 30 oz. milk per head constitutes the optimum daily requirement.

(20) D. G. Karve. "Poverty and Population in India." Oxford University Press, 1936.

state of nutrition of school children in South India[21] The authors point out that children frequently have to subsist on diets costing only Rs 3 8 0 per month At present prices it is manifestly impossible for an adequate quantity of whole milk to be included in the diets of such children* In a recent investigation in Calcutta[22] it was, in fact, found that in three out of four hostels (two being children's orphanages) no milk or milk products could be included in the diet on account of their relatively high price

Need for increasing and cheapening milk production

The conclusions of this discussion are two fold In the first place it is essential that the production of milk in India should be vastly increased if the population is to have sufficient quantity of this product in the diet It is estimated that the output of milk would need to be at least doubled in order to provide even a minimum requirement In the second place such an increase in production would fail to achieve its object unless the price of milk could be reduced or the income level of the population could be raised The possibility of achieving an increased production of milk will be dealt with in the second part of this report In the present part which deals with the utilisation of milk for liquid consumption and for manufacture, the second objective namely, to ensure that the price of milk is within the purchasing power of the majority of the population, must be constantly kept in mind

(21) W R Aykroyd and B G Krishnan "The State of Nutrition of School Children in South India, Part II" *Ind Journ Med Res* 24 707 (1937)

(22) H E C Wilson, B Ahmad and D N Mullick "A Diet Survey of Some Families and Institutions in Calcutta" *Ind Journ Med Res* 24 161 (1936)

*Reference may be made to Appendix IV in which the provision of milk for children of school age is discussed in some detail

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CHAPTER II.—General discussion on the trend of development of the dairy industry.

Organised dairying in India may be said to have a two-fold origin ; first the introduction of cream separators in 1889[1], and second, the establishment of large scale dairy farms by the military authorities, the first of which was started at Allahabad in 1891. Of these two developments the latter was to prove the most important, since it led indirectly to the creation in 1920 of the post of Imperial Dairy Expert. This in turn provided a focussing point for the development of the industry and an impetus to the introduction of modern methods of handling milk. It may indeed be said that the main objective has been the introduction of Western methods into Indian dairying practice with the object of placing on the market a better quality product. Thus the policy of pasteurising and bottling milk has been encouraged and stress has been laid on the introduction of factory methods of manufacture, particularly for the production of butter.

Origin of organised dairying.

The indirect influence of the Military Dairy Farms has therefore played a large part in initiating organised dairying in India. There is, however, one disadvantage in basing the dairying development of a country on the requirements of a particular section of the population, since such a development may fail to meet the needs of the majority of consumers. This danger is the more serious when those catered for, namely Europeans, do not have the same dietary habits nor the same standard of living as the great mass of the Indian population. The unsuitability of European products for Indian consumption is clearly shown in the following figures relating to the utilisation of milk produced on the Military Dairy Farms.

	Milk (lb.).	Butter (lb.).	Cream (lb.).
British Troops	13,095,577	1,041,599	194,157
Indian Troops	3,965,817	688	36

It will be seen that only one-quarter of the milk used for liquid consumption was consumed by Indian Troops, and that their consumption of butter and cream was negligible. This is in no way quoted as a criticism of the policy of the Military Dairy Farms, which were established specifically to supply milk and milk products to British Troops and Military Hospitals : the needs of Indian Troops are catered for in other ways,—for example, by the Military *Ghee* Heating Depot at Agra. The difficulty only appears when the policy adopted at the Military Dairy Farms is used as a model for the development of the dairy industry in the country as a whole.

When the post of Imperial Dairy Expert was created and the problem of developing the dairy industry had to be faced no accurate

(1) It is, however, significant to note the very limited growth of the use of cream separators in India. At present there are probably less than 4,000 in the country. In comparison there are, for instance, over 50,000 in New Zealand alone although that country handles only a fraction of the quantity of milk produced in India.

information was available regarding the relative importance of various milk products in the Indian dietary Moreover, no experiments had been carried out to determine for example the feasibility of organising village milk supplies on a co operative basis or of adapting Western manufacturing methods to Indian conditions It was therefore inevitable that development should tend to be planned on lines which had proved successful in the more limited sphere of army requirements It was known too from import returns that there was a market for such products as butter and further that this market would probably provide a more lucrative return to the milk producer than he could secure from the sale of indigenous milk products such as *ghee* and *khoa* Such facts account for the prominence which has hitherto been given to the provision of high grade milk and of butter in official dairying circles

At the date of my inquiry however a number of factors had combined to clarify the whole subject In the first place an extensive marketing survey had just been undertaken(2) and information was therefore available as to the relative importance of the various milk products produced in India In the second place much new and valuable information had been collected as a result of the appointment of the Animal Husbandry Expert to the Imperial Council of Agricultural Research In the third place a number of projects had been initiated in such directions as co operative dairying the establishment of village separating stations and the running of modern processing plants the results of which I was able to inspect personally These three factors have provided a solid foundation of knowledge and experience on which in my opinion the future development of the dairy industry must be based I propose at this point to discuss in some detail the main considerations which I feel to be of outstanding importance in planning any future policy for the industry

Market requirements

The first requirement of any national industry is that it should meet the needs of the great mass of the population Thus it is essential in considering the development of the dairy industry, to ensure that it caters for the existing taste and dietary habits of the Indian people The only available means of determining this is to ascertain the present demand for the various products available A rough indication of the demand is provided in the provisional estimates of milk production obtained in recent provincial marketing surveys The results of these surveys have for convenience been combined in a single table (Table 9) It will be seen that roughly one third of the milk produced is sold as liquid milk Of the manufactured products the output of *ghee* is far in excess of that of all the remaining products accounting for 75 per cent of the milk utilised for manufacture It is significant that the quantity of milk used for *ghee* production is substantially greater than that sold for liquid consumption There is indeed no doubt that the production of *ghee*

(2) general direct o
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must be considered as the most important single factor in any scheme of development of the dairy industry. Of the remaining products, *khoa* and other indigenous milk products account for nearly 15 per cent. of the milk used for manufacture, while the inclusion of *dahi* (curds)—another indigenous dish—would bring this figure to 20 per cent. Butter accounts for only 2 per cent. of the manufactured products. Moreover it will be shown later that nine-tenths of this is so-called 'country' butter, which is used almost entirely as a basis for the production of *ghee* in the household. Only one-tenth is 'creamery' butter, which therefore occupies a position of almost negligible importance in Indian dairying. Cream and ice-cream also account for very small quantities of milk, while cheese production is practically non-existent.

The same general conclusions may be drawn from figures showing the calculated values of the total output of liquid milk and milk products. These are given in Table 10. Liquid milk and *ghee* head the list with values exceeding 100 crores of rupees, though it may be noted that no allowance has been made for the value of *lassi* (butter-milk) formed as a by-product of *ghee* and invariably consumed by the cultivator and his family. The value of indigenous milk products (including *khoa* and *dahi*) is estimated at roughly 80 crores of rupees, while butter (both 'country' and 'creamery' make) total only 3 crores. Cream and ice-cream are valued at a little under 2 crores of rupees.

These figures show clearly that the items of major importance in Indian dairying are liquid milk, *ghee*, and other indigenous milk products. Western products such as butter and cheese are scarcely used except by Europeans and a small number of educated Indians who have acquired a taste for them.

It may, however, be argued that the figures so far discussed do not include imported milk products, and that these constitute a substantial item which must be taken into account. Reference to import statistics indicates that this view is untenable. A rough calculation shows that the quantities of butter, cheese and condensed and dried milk imported annually into India are equivalent to about one million maunds of milk. India's milk production is estimated at about 700 million maunds. Imports represent therefore less than 0.15 per cent. of the country's total output of milk. Again, the value of these imports is given as about Rs. 78 lakhs(3). It has already been shown that milk and milk products produced in India are valued at some 300 crores of rupees. The milk products imported are therefore valued at less than half of 1 per cent. of the total value of products produced in India. To put the matter more strikingly, an increase in the value of *ghee* by only 1 per cent. would add more to the wealth of the dairy industry than the replacement of the whole of the imported milk products by home-produced articles.

(3) Figure obtained from the Annual Statements of Sea-borne Trade of British India.

This is a point of fundamental importance. Proposals have for example been made to spend a very considerable sum in setting up a Government Experimental Creamery which could be used for investigating the production of condensed and dried milk and of butter on a factory scale under Indian conditions The object of the scheme is largely to demonstrate that imports of these products could be replaced by products manufactured in India Without considering the feasibility of such a scheme (which is dealt with in a later chapter) it may, I think, be argued on grounds of principle alone that available funds should be chiefly devoted to the encouragement of the major products of the dairy industry, rather than to branches of manufacture which are of such minor importance to India as a whole Again, persistent efforts have been made to formulate standards of quality for creamery butter produced in India, in the expectation that this will lead to improved methods of production and marketing The provision of such standards for butter is undoubtedly desirable, but the formulation of quality standards for *ghee* (and even for *khoa*) is an infinitely more urgent subject for consideration by Government These examples are taken to illustrate in a concrete form the contention which I have already urged, namely, that the first requirement in developing the dairy industry is to ensure that it will cater for the taste and dietary habits of the Indian population

Special difficulties involved in dairying under Indian conditions

The second requirement of an industry is that it should be designed to suit local conditions of production, collection and transport of raw materials In this connexion it might be well to make a few brief comparisons between rural conditions in India and those in certain typical dairying countries India is essentially a country of small holdings In the Punjab, for instance, over 40 per cent of holdings are of less than 5 acres, while only 12 per cent are over 20 acres For Bombay the equivalent figures are 48 per cent and 12 per cent and for the United Provinces 52 per cent and 7 per cent In the latter Province the average area of land per worker is 2 5 acres while for Assam, Bengal, Bihar and Orissa, it is 3 acres(4) These figures may be compared with those of Denmark, where only 10 per cent of holdings are below 5 acres and where the average holding is just under 40 acres In Great Britain the size of the average dairy farm exceeds 100 acres, and in New Zealand and the United States dairy farms average about 150 acres(5)

The marked difference between the average size of holdings in India and in these typical dairy countries is parallelled in the number of cattle per holding Denmark has an average of about nine cows per holding and the United States about twelve In Great Britain dairy herds average about 25 head, a figure also shown by New Zealand India presents an entirely different picture The typical cultivator possesses a pair of bullocks with one or at the most two

(4) Figures obtained from Census of India, 1931, and from other sources

(5) Figures obtained from Denmark Agriculture, New Zealand Official Yearbook, U S Agricultural Statistics, and other sources

cows (usually of a draught or nondescript breed) and perhaps one or two buffaloes for milk production(6). There are practically no specialised dairy farms, the production of milk or *ghee* being subsidiary to small scale crop farming. In consequence of this, as well as of the poverty and lack of education of the cultivator, methods of milk production are crude and facilities for collection are primitive. This difficulty is intensified by lack of communications between villages and main roads, and by absence of suitable forms of transport. Moreover, there are also special difficulties connected with the climatic conditions in India. The average temperature is high, reaching figures well over 100°F. during the hot weather. Yet there is often a complete lack of water suitable for cooling, while flies and dust are abundant sources of contamination of the milk. In the monsoon period the village roads are frequently so badly flooded as to be impassable. It may be mentioned, too, that the total output of milk per village is usually low, an average figure being less than 1,500 lb. per day.

Under these circumstances the collection and handling of milk at central depots under factory conditions would be fraught with difficulty. Personal inquiries among those responsible for running butter-making creameries revealed the fact that on arrival at depots the milk is frequently sour and unfit for the production of a high quality product. The separated milk from such a poor supply is only fit to be converted into crude casein, and is wasted as a source of human food. In a country like India where there is such an urgent need for ' first-class ' protein in the diet, such a wastage of valuable food is to be deplored.

An impartial survey of the present position leads one to the conclusion, in fact, that the evolution of the indigenous milk products which are peculiar to India (*ghee, khoa* and *dahi*) has largely been due to the fundamental difficulties involved in handling milk under the conditions described. *Ghee* and *dahi* are made directly by the producer from naturally soured milk, so that high atmospheric temperatures and casual contamination do little damage to these products. *Khoa* on the other hand is a form of milk rendered transportable by partial desiccation—a process which also partially sterilises it and thus improves its keeping quality. It is very doubtful whether one could apply to the manufacture of these products(7) the type of factory system of dairying which has been evolved to suit the products and the climatic conditions of countries situated in temperate zones.

India's population is predominantly rural.

This raises a further point. The third requirement of any industry is that it should fit into the general economy of the country. In this connexion it is significant to note that the development of a factory system of dairying has only been successfully achieved in

(6) In a recent village inquiry carried out in important breeding tracts in Northern India the following figures were obtained :—Number of holdings surveyed 7,627 ; numbers of cows—dairy breed 1,363 ; draught breed 6,327 ; nondescript 4,126 ; number of buffaloes 10,377.

(7) With, perhaps, the exception of *khoa*.

countries which either have a large urban population or a large export market In Great Britain, for example, where 80 per cent of the population is urban and only 20 per cent rural, nearly 90 per cent of home produced milk and milk products are consumed by the former In the United States where the urban population is roughly 60 per cent of the total, 75 per cent of home produced milk and milk products are sold for urban consumption Denmark and New Zealand do not possess sufficient urban populations to absorb their available supplies of milk, but these countries are able to export large quantities—the ratio of milk products exported to milk products retained being about 4 1 or 5 1 India is in a very different position While the ratio of rural to urban population in Great Britain is, for example, 1 4, the ratio in India is 9 1(8) The urban population provides therefore only a very limited market for milk, and it may be said that the industry has in large measure to find its market in the producing areas themselves To put the situation somewhat crudely, for every seer of milk sold to towns, nine seers must be retained for consumption in rural areas either by the cultivator himself or by his village associates Moreover there is little chance of building up a large export trade of milk products from India, partly because of fierce competition from countries which have a more favourable climate for the manufacture of milk products consumed by Western nations, and partly because India is not yet producing sufficient milk to meet even her own needs

The fact that the rural community constitutes the largest potential market for milk and milk products affects the whole possibility of introducing a factory system of dairying into India Such a system entails difficulties even in highly industrial countries chiefly on account of the by products of manufacture In a recent report (9) on the British dairy industry it is, for example, stated that " where manufacture is undertaken on the farm the by products are available for immediate use The extension of factory manufacture has however given new importance to the problem of the disposal of by products " If the manufacture of *ghee* was to be undertaken on a factory scale in India there would inevitably be large accumulations of separated milk at the manufacturing depots Such accumulations of separated milk have in fact already proved a source of embarrassment to butter making creameries It has been pointed out that the conversion of such milk into casein is undesirable on nutritional grounds The only alternatives would be either to return it to the cultivator or to convert it into condensed or dried milk The former procedure does not appear feasible There would be difficulties in returning the large volumes of separated milk to the villages including the risk of souring during transportation, particularly at the high temperatures experienced in India There would also be the risk of spreading disease through milk which had been indiscriminately bulked , there would be the difficulty of ensur

(8) See Table 11

(9) Report of the Milk Reorganisation Commission for Great Britain 107 H M Stationery Office, 1936

ing the sterilisation of the containers after return to the cultivator ; and finally, it is more than likely that the cultivator and his family—always conservative in matters relating to diet—would refuse to drink the returned milk. The second alternative, namely, to condense or dry the separated milk, is equally open to objection. Apart from the technical difficulties involved through the poor keeping quality of the milk, the market for condensed and dried milks in India is strictly limited and is largely confined to proprietary brands. In any event once this very limited market was saturated the only alternative would be to return the dried product to the cultivator—obviously an uneconomic procedure even if he could be persuaded to use it in his diet. It will be seen therefore that any attempt to adopt a factory system of dairying in India would involve fundamental difficulties which it would be extremely difficult to overcome.

Need for a new outlook.

It is apparent from this discussion that any attempt to develop the Indian dairying industry by the piece-meal introduction of Western methods is to be deprecated. What is needed in Indian dairying is a new outlook and a new technique ; an outlook which recognises the special nature of India's problems and a technique which is designed to solve these problems. The lines along which such a technique might be developed are dealt with in subsequent chapters. It will be well, however, to indicate at this stage the main directions in which I feel that progress should be looked for.

Requirements of the rural population.

The first essential is, to my mind, to ensure that an adequate supply of milk and/or milk products is available for consumption by the rural population. The tendency of the Indian cultivator (as indeed of most agricultural producers) is to sell as much of his products as possible for cash, even if this entails a shortage of essential nutrients in his own diet and that of his family. This fact was repeatedly brought to my notice during visits to villages and by those working in close touch with village communities. Little can be done to check this tendency in regard to the sale of milk for liquid consumption in towns. The market is relatively lucrative and sales of milk provide a valuable addition to the cultivator's income. Moreover it is arguable that such sales do not necessarily result in any decreased milk consumption in the cultivator's own household, since with increasing prosperity he will tend to expand his production, leaving a margin for home consumption at least as large as formerly. With the cultivator whose holding is remote from the market the same argument does not hold. At present such a cultivator will probably utilise most of his milk for the production of *ghee*. This is most advantageous since, in addition to selling the *ghee* for cash, he retains the *lassi* (butter-milk) for the use of himself and his family. It is essential that any alternative system of manufacture which might replace present dairying practice should still leave such valuable milk by-products with the cultivator. It has already been noted that large-scale factory dairying fails to meet this criticism.

Nevertheless, there is no doubt that the present methods of handling milk and of producing indigenous milk products are crude and primitive Such methods only survive because the cost of labour is not taken into account and the class of purchaser is too poor or too uneducated to be able to discriminate between a good and a bad quality product The second essential is, therefore, to introduce improved methods of production This should be effected by evolutionary rather than revolutionary changes of technique One essential step in any attempt to improve methods of production is I believe, the combination of producers on a village industry basis(10), where the handling of larger quantities permits of the employment of more specialised labour and where the output is sufficiently large to justify the use of improved types of equipment At the same time a village industry system avoids (so far as the manufacture of milk products is concerned) the inherent difficulties involved in the transport of milk which would be entailed in a large scale factory system One of the great advantages of retaining industries within the village is that the by products of manufacture are still available for the use of the cultivator At the same time this degree of centralisation or manufacture is sufficient to call for some form of co operative marketing, from which the cultivator should benefit materially

Need for improved methods

This brings me to the third essential, namely, the need for improved methods of marketing At present the marketing of milk and milk products is chaotic a situation which is inevitable when small producing units market their own supplies Improvement could be effected in various directions Facilities could be provided for the grading and sale of more uniform products and of products of higher quality A larger number of accessible markets could be established in producing areas where the present arrangements for the marketing of milk products are inadequate And, by these and other similar means, the producer could be furnished with a more powerful bargaining weapon in disposing of his produce and could avoid the heavy toll on his income which is associated with the existence of numerous intermediaries between producer and consumer

Need for better marketing facilities

The general conclusions of this chapter may be summarised as follows —First, attention should be concentrated on the production of indigenous milk products such as *ghee, khoa* and *dahi* and not on products of Western origin such as butter and cheese Second, the large scale factory system of dairying, which has been developed in temperate zones is of very limited application in a country having a tropical climate, primitive methods of production and inadequate communications and transport facilities Third, developments in the dairy industry must

Conclusions

(10) It is, I believe most important to differentiate between the factory system, where milk is collected to a central depot from a number of villages, and the village industry system where the milk is retained within the village itself

be primarily designed to meet the needs of the vast population of small cultivators rather than those of the very limited urban population. Fourth, for this purpose (as well as to ensure better methods of production of indigenous milk products) a village industry system (as distinct from a factory system) of dairying should prove the most effective form of dairy organisation. Fifth, as a general means of improving conditions in the dairy industry it is essential that more adequate facilities should be provided for the proper grading and marketing of milk and milk products.

I have attempted in this chapter to give a brief outline of the general lines along which I consider Indian dairying should advance. In the next four chapters I shall deal in detail with the specific problems involved in handling liquid milk and in manufacturing milk products. I hope, however, that in considering these detailed suggestions, the five main contentions mentioned above will always be kept clearly in mind.

CHAPTER III—The Production, Collection, Processing and Distribution of Milk for Liquid Consumption

Introduction

The problems involved in the production and distribution of milk for liquid consumption have frequently been stated as if they were limited to the supply of milk to large centres of population It is true that the consumption of milk in cities is low in comparison with that in rural areas, particularly as no supply of *lassi* (butter milk) is normally available under urban conditions At the outset I should, however, again emphasise the fact that the urban population constitutes a very small proportion of the total population of India This fact is clearly shown in Table 11(1) Eleven per cent of the population are classed as urban, and 89 per cent as rural It may probably be assumed that the special difficulties associated with city milk supplies only arise in urban centres with populations exceeding 100 000 Less than 3 per cent of India's population reside in cities of this size It is true that the urban population is increasing at the expense of the rural In 1911 9 4 per cent of the population were classed as urban, in 1921 10 3 per cent and in 1931 11 0 per cent This increase is however, extremely slow and does not show any sign of acceleration The greatest increase has moreover taken place in towns having populations of 20 000 to 50,000 and not in the cities of 100 000 and over In view of these facts it would I believe be a grave mistake to limit consideration of the problems of milk production and distribution to a section of the community which represents such a small fraction of the total population In this connexion it might also be timely to point out the rough distribution of the rural population Over 40 per cent of the rural population live in villages of under 500 inhabitants while about 45 per cent live in villages with populations between 500 and 2 000 For India as a whole the average village population is roughly 450 These figures re emphasise the fact that in facing the problems of milk production and distribution in India one is dealing with an essentially rural population

Many of these problems are more or less common to all areas, irrespective of population densities I propose to deal with such problems in this chapter Special considerations which apply only to city milk supplies will for convenience be dealt with separately in Appendix II

Before turning to a detailed consideration of technical problems I should however once again stress the fact that the essential point to be borne in mind throughout this discussion is the need for providing a supply of pure milk *within the purchasing power of all classes of the population* In an earlier chapter I have drawn attention to the urgency of increasing milk consumption in India and I have indicated that the present low consumption of milk is largely attributable to the low income level of the population It is essential therefore that any improvement in the methods of production and distribution of milk should be effected without adding materially to its cost

(1) Census of India 1931

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(1) Census of India 1931

Owing to the very varied conditions existing throughout India it would be useless to attempt a detailed description of the methods employed in the production and distribution of milk destined for liquid consumption. In towns much of the milk is produced and sold by local *gowalas* (professional milk producers) who keep four or more cows or buffaloes. Such animals are stall-fed and get little or no grazing. In large cities very much larger herds are kept in stables by large milk dealers who purchase cows and buffaloes and dispose of them when the milk yield becomes uneconomic. In villages, on the other hand, milk production may be more or less a side-line, and the cattle are seldom sufficiently well-fed to give satisfactory milk yields. Wherever cattle are kept, however, the technique of milk production is very similar. The udders of the cows may or may not be washed or wiped with a cloth. Immediately before milking the calf is allowed to suckle (an almost universal custom) and the cow is then hand-milked, wet milking being usually employed. The milking vessel is generally a circular pot with a wide mouth, which is held between the knees of the milker. The milk is subsequently transported to the nearest market by head load, bicycle or cart. The vessels used frequently have no lids, and the mouth of the vessel is therefore generally stuffed with grass or straw. After use the vessels are scoured with mud and ashes, rinsed with water, and occasionally 'smoked' over a fire.

Present methods of production.

It is obvious that much improvement in methods will be necessary if the hygienic quality of the milk supply is to be improved. In a country like India, with a tropical climate and inadequate communications, it is specially important that milk should be produced with as little contamination as possible if it is to have a reasonably good keeping quality. Otherwise there is a serious risk of spoilage. It is therefore disappointing to find that the cultivators and *gowalas* show such a complete lack of knowledge of the most elementary practices associated with clean methods of milk production. Their poverty and their consequent lack of equipment will of conrse tend to discourage the adoption of progressive methods.

While this lack of knowledge on the part of cultivators and *gowalas* is perhaps inevitable. it was still more disappointing to find the complete absence of interest displayed in this matter by officials associated with the agricultural and veterinary services and with the Imperial Dairy Expert's section. I found, for example, that it was almost impossible to obtain reliable figures in regard to such an elementary question as the keeping quality of milk, how it differed at different seasons and with different methods of handling, and how it could be improved under village conditions of production. The Gerber 'dirt' test appeared to be unknown, or if known. not employed. In only one or two centres was I able to see the results of more accurate tests, such as the methylene blue reduction test and the plate count, which form essential weapons in the investigation and control of production methods. It may be argued that there would be serious difficulties in applying accurate tests under village

conditions, even for purposes of investigation This argument, even if tenable, would not apply to conditions at agricultural colleges and other similar centres where facilities for laboratory investigation are available

Need for investigation

Matters such as these may appear elementary and of little practical importance It is significant, however, that in every dairying country investigations along such seemingly elementary lines have formed the foundation of dairying technique Thus the first problems investigated at the National Institute for Research in Dairying at Reading (England) were concerned with the study of the various factors concerned in the production of clean milk, including such apparently simple questions as the shape of the milk pail and the cleanliness of the milking stool(2) Similar investigations have been carried out by workers in the United States Department of Agriculture(3) Moreover it cannot be maintained that, since the subject has been so carefully investigated by Western workers, there is no need to duplicate the work in India Conditions in India differ fundamentally from those in temperate climates The cultivator is poorer and is therefore usually unable to purchase special dairying equipment The average temperature is very much higher though the intense sunlight is credited with a strong sterilising power Fuel is scarce and water for cooling is seldom available or, if available, effective It is, indeed, obvious that under such circumstances methods of producing and handling milk may have to be greatly modified from those employed in countries situated in temperate zones(4) *A technique suitable for tropical and sub tropical conditions must be devised to meet these special difficulties*

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(2) E G Knight K Freear and R S Williams "A Study of Factors concerned in the Production of Clean Milk" King and Son Ltd, London (1920) See also "Studies concerning the Handling of Milk" Ministry of Agriculture Bulletin No 31 H M Stationery Office London (1931)

(3) S H Ayers, L B Cook and P W Clemmer "The Four Essential Factors in the Production of Milk of Low Bacterial Content" U S Department of Agriculture, Bull 642 (1918)

(4) It would, perhaps, be desirable to give a concrete example of the point which I desire to emphasise At several villages during my tour I had opportunities of seeing the methods adopted in cleaning vessels used for milk This usually consisted of scouring the vessel with a mixture of earth and wood ashes, which was subsequently rinsed out with well water and then stood in the sun This method was usually pointed out to me as an example of the dirty methods employed by the cultivator It is however quite likely that the results are, in practice far more satisfactory than one might suppose In the absence of soda and refined abrasives (which form the basis of ordinary scouring powders) a mixture of earth and potash (ashes) would form a cheap but efficient cleaning mixture, while the lethal action of the sunlight might possibly be found to destroy any contaminating organisms left in the vessel after rinsing But the point is that even a simple matter such as this has not been investigated so that no reliable guidance can be given to the cultivator as to the directions in which his methods are sound and the lines along which they might be further improved

In working out such a technique, two general problems are involved. In the first place it will be necessary to investigate the utility of various tests under Indian conditions. A number of tests are already available; for example, the Gerber 'dirt' test, the acidity and alizarol tests, the ordinary test for keeping quality, the methylene blue reduction test and the plate count and coliform test. Each of these has been found to have its special uses in Western dairying countries, but the utility of each test would need to be investigated afresh under Indian conditions. For example, the keeping quality test is carried out in Great Britain at 60°F., a temperature obviously too low for use in India. Again, it would be necessary to determine what relationship existed between keeping quality and tests such as the plate count and methylene blue reduction test, since the normal bacterial flora of milk in India may differ markedly from that of more temperate countries. It would also be desirable to pay special attention to the feasibility of devising special tests of quality for use under village conditions, the essential criteria of such tests being simplicity, rapidity and cheapness.

Suggested problems.

In the second place these tests would need to be applied to the solution of the practical problems of clean milk production. Fundamental subjects for investigation would be the effect of different methods of cleaning and milking the cow and of cleaning and sterilising milk utensils on the quality of the milk produced. In this connexion the difficulties involved in the use of steam under village conditions would need to be investigated, and alternative methods such as scalding and heating over a glowing fire (perhaps the origin of the present ineffective method of smoking utensils) would have to be studied. In all such work local habits and requirements would require to be taken into account. For example, the various types of milk container have obviously been evolved to suit the special circumstances of collection and transport. Thus for head loads a relatively light circular vessel is preferred, for bicycle transport square cans (such as kerosene tins) are employed, while for hilly districts long narrow containers suitable for carrying on the back (and often constructed of bamboo) are used. The materials of construction include earthenware, brass, copper, aluminium and tinned iron. Some of these vessels are clearly of an unsuitable design for use as milk containers, but in re-designing them or in suggesting alternatives it is essential to ensure that the new vessels meet local habits of transport. Apart from these special points, the influence of more general factors would need careful study. For example, investigations would have to be made into the extent of contamination of milk by dust and by flies, the influence of these contaminants on the keeping quality of the milk, and the means by which such contamination can be avoided. Again, the possible influence of the quality of the water supply on the contamination of milk would need to be studied. Such investigations would have to cover all seasons of the year, since the technique might have to be modified to suit the monsoon, hot weather and cold weather periods.

These suggestions are not exhaustive, but they serve to show the very wide field of study which is urgently needing attention. Until these various questions have been properly investigated it is, in my opinion, useless to attempt to give expert advice to the cultivator or *gowala* on methods of improving the quality of his milk.

Application under village conditions

Moreover it will be equally necessary to show that the improved methods are capable of application under village conditions, and that they result in the creation of a better market for the liquid milk. Attempts to foster improved methods of producing and handling milk have been made at a number of centres, among which I might perhaps make special mention of the Telankheri Co operative Dairy at Nagpur, the Co operative Societies at Parbatpur, U P and other neighbouring villages, and Singhal's Dairy at Itaura, U P — all of which I was able to visit personally. While these and similar projects are doing useful work, I feel that their value would be greatly enhanced if the production, transport and quality of the milk could be more carefully and systematically studied in relation to the methods of production employed. At present there is for instance, no reliable information regarding the quality of the milk as it reaches the consumer, except in so far as this can be measured by the number of complaints received and the trend of sales. With a little organisation it should be possible to check the quality by more accurate tests and so have an objective standard by which the success of any fresh interprise or new technique could be judged.

The processing of milk

Even if methods of production can be improved the question still arises as to whether milk for liquid consumption requires any treatment between production and delivery to the consumer. In this connexion it should be clearly understood that in India the problems associated with milk borne disease do not normally arise. This is due to the almost universal custom of boiling milk before it is consumed, a practice common to both the Indian and European populations. Consequently any processing which is carried out between the production of the milk and its delivery to the consumer need have only one object, namely, the improvement of the keeping quality of the milk.

This fact is of considerable significance in deciding at what stage processing should take place. If, as in Western countries processing is largely employed as a safeguard against milk borne disease the ideal method is to treat the milk (usually by the process of pasteurisation) immediately before it is bottled. This limits the opportunity of subsequent re infection during handling. Such a method is moreover, eminently suitable for Western countries where the relatively low temperatures allow the milk to be kept in a raw state for comparatively long periods. In a tropical climate however, the temperature seriously affects the keeping quality. It has for instance been found that milk stored at 100°F will only keep 'sweet' for about a quarter of the time of milk kept at 60°F (5).

(5) Unpublished data

That is to say, milk which would sour within 24 hours at 60°F. will sour within 6 hours if kept at 100°F. It follows that under Indian conditions any processing of the milk which may be necessary should take place as soon as possible after production. This does not appear to be the present practice. Pasteurising plants are usually located in the cities, the milk being transported in a raw state. It is very questionable whether such pasteurisation has anything but a 'sales' value, especially as I observed that the process was usually associated with the sale of milk in bottles—a form of milk distribution which is far too costly for the bulk of the milk consumed by the population.

Apart from deciding at what stage processing should be carried out, the question arises as to whether such processing should be based on heat treatment or on refrigeration or on both. A combination of the two is, of course, ideal, since the number of viable organisms is not only reduced to a minimum by heat treatment but is retained at a very low figure by effective chilling. On the other hand this invitably adds very materially to the cost. The following brief notes may be made regarding the two processes.

Processing by heat.

It has already been mentioned that the boiling of milk is an almost universal practice among all sections of the population in India. This does not mean that all milk is sold as boiled milk : the custom is to boil milk in the household. At the same time much of the milk which is sold in the bazaars is boiled : such milk, is, in fact, frequently kept simmering for long periods. In one survey 250 out of 340 seers of milk which was sold daily through *halwais* was heated milk(6).

Processing be heat has, of course, one great advantage in a tropical climate, since it is easier to keep milk hot than cold. It was interesting to find that at certain Military Dairy Farms the pasteurised milk is not cooled during the hot weather, but is sent out hot in bottles. This practice, however, involves two difficulties. In the first place it is now known that certain bacteria are not only able to survive pasteurisation, but that they can multiply at pasteurising temperatures. If milk is kept at such temperatures for long periods there is a risk of souring or spoilage as a result of the activities of these bacteria. In the second place it is not yet known to what extent continued heating affects the nutritive value of milk. This question is of particular importance in regard to the bazaar practice of simmering milk for long periods. In view of the widespread nature of this practice, it is very desirable that investigations should be undertaken to determine whether such continued heating does reduce the nutritive value of milk.

Turning to the general question of improving the keeping quality of milk by heating it will be realised that, if such processing is to be carried out soon after production (as has been recommended in an earlier paragraph) it will necessitate the installation of suitable processing plant either in the villages or at central collecting depots

(6) R. L. Anand and A. C. Aggarwala. "The Milk Supply of Lahore." Punjab Board of Economic Inquiry, Publication No. 28 (1933).

situated in producing areas The requirements of the market will decide which of these two alternatives is feasible for a milk supply to a local town (say, 5 to 15 miles distant) the former is probably the ideal, on the other hand for city milk supplies drawn from distances of 50 to 200 miles, central collecting depots would be necessary, particularly if the milk has to withstand a long period of transport In such circumstances it would almost certainly be necessary to combine heat treatment with refrigeration

If heat treatment is to be carried out in villages, it is essential to devise a suitable small-scale plant for the purpose Existing types of equipment are too expensive and are not designed to meet the special needs of a primitive village supply It is, for example, desirable on hygienic grounds that the container in which the milk is heated should also be capable of being used for the transport of the processed milk Otherwise with the relatively poor facilities which usually exist in villages for sterilising utensils, there is a serious risk of contaminating the milk when transferring it from one container to another Again, such a plant must be of simple design, easy to operate and with as few mechanical parts as possible, since it will have to be handled and repaired by relatively unskilled labour The nearest analogy in Western dairying is the scalding of milk in a jacketed container,* a procedure which is perhaps crude but is certainly effective The requisite temperature and time of heating of the milk would, of course, have to be determined by experiment to ensure that it suited Indian conditions A cheap and simple plant of this character has in my opinion far greater potentialities for Indian dairying than any of the more elaborate types of equipment which are found on the market

As regards heat treatment at collecting centres, equipment of greater capacity and more efficient design could be installed, since the through put of milk would be sufficient to meet the larger overhead charges But here again it should not necessarily be assumed that the most effective combination of temperature and time of heating is that usually employed in Western countries, *i e*, holding at 145°—150°F for 30 minutes Extensive experiment would be necessary, using plants run on different principles (for example, holding pasteurisation, 'flash' pasteurisation, and high temperature short time pasteurisation) and assessing the results by means of carefully conducted laboratory tests It would in addition, be essential to investigate the cost of processing In one co operative venture which I inspected the installation of expensive pasteurising machinery resulted in an annual deficit of roughly Rs 6 000 on an average turn over of only 300 lb of milk per day In this instance neither the turnover of milk nor the location of the plant(7) justified the installation of pasteurising equipment Failures of this kind have an unfortunate effect in discrediting other more feasible attempts to improve methods of handling milk This points to the urgent need

(7) This plant was situated at a large hill station where the temperature conditions for the greater part of the year made pasteurisation quite unnecessary

*The inner container being removable

for including in all such investigations a careful study of the costs of processing.

Milk can be cooled by means of water or by artificial refrigeration. So far as village milk supplies are concerned it is doubtful how far artificial refrigeration could be successfully applied. Small-scale refrigerating coolers are on the market(8), but for Indian village conditions they would probably involve too high a capital cost and too great a cost of maintenance to be economically feasible. An alternative method of refrigeration is the use of dry ice (solid carbon dioxide) which is now being manufactured in increasing quantities in India. It is likely that the cost of this would also prove prohibitive for village use. The cost of 'dry ice' is still considerable(9). Moreover the difficulties of transporting this product to villages and of storing it there without wastage appear to be almost insuperable. It seems therefore that water cooling is likely to be the only practicable method available for village milk supplies. It is, however, questionable whether such cooling would in any event be of practical value unless the milk could subsequently be transported in insulated containers, since the very warm atmospheric conditions will quickly raise the temperature of the milk to a level at which contaminating bacteria rapidly multiply. Although the subject is worth attention, it seems likely that under village conditions the heating of milk will prove to be a more effective means of ensuring a satisfactory keeping quality than any attempt to cool milk.

Cooling and refrigeration.

On the other hand artificial refrigeration should be of great value in the transport of milk over long distances, as, for example, in the despatch of milk from distant producing areas to large cities. The technique of refrigeration under creamery conditions has been extensively studied, and many suitable types of plant are already on the market. So far as Indian conditions are concerned the problems of the large scale refrigeration of milk are likely to be concerned with refrigerated transport rather than with refrigeration at the creamery, which presents few difficulties. The problems involved in transport are due to the fact that during the hot weather the internal temperatures of unrefrigerated railway trucks reach extraordinarily high levels. A series of tests carried out in runs between Bombay and Jhansi in mid-May showed, for example, that the internal temperatures of railway trucks reached 120° to 130°F., and seldom fell below 90°F.(10).

Several types of refrigerated transport might be investigated. The use of refrigerated vans would probably be ideal, but costly. An alternative would be the use of dry ice in specially constructed and insulated churns, a subject on which certain preliminary experiments

(8) See, for instance, the Reports of the Agricultural Machinery Testing Committee of the Ministry of Agriculture. H. M. Stationery Office.

(9) Figures obtained from Indian manufacturers showed that 'dry ice' could be purchased at 2 to 2½ annas per lb. A crudely made insulated container designed to store 220 lb. of 'dry ice' showed a 10 per cent. loss per day.

(10) Information obtained through the courtesy of the Railway Board.

have already been carried out(11). A further alternative would be the use of large insulated tanks, though it is very doubtful whether these would prove sufficiently effective under the severe temperature conditions of India

The whole question of refrigeration is one which merits extensive investigation Great progress has been made in this direction in the United States and other countries, and an effective method of refrigeration might well revolutionise the methods of handling milk in a tropical climate In this connexion I suggest that an attempt should be made to combine the study of the refrigerated transport of milk with the recent developments in refrigerated transport sponsored by the army authorities It is, however, again necessary to stress the fact that in a country like India the prime consideration is cost, and that no method could hope for extensive employment unless it involved an absolute minimum of expenditure

The distribution of milk

While the problems involved in the production and processing of milk are considerable, their solution will be valueless unless a satisfactory means of distribution is also evolved, for the handling of milk during distribution provides unlimited opportunities for its re contamination and adulteration So far as specific methods of distribution are concerned the great variety of conditions in urban and rural centres of population makes detailed recommendations impossible Thus in some areas it is usual for all milk to be sold in bazaar shops , in others some of the milk is delivered to the purchaser's house and some is bought at retail shops , in others again, the cow is driven from door to door and milked in the presence of the customer All that I can do here is to indicate possible methods of ensuring that the cleanliness (*i e*, lack of dirt) and purity (*i e*, absence of adulteration) of the milk is retained throughout distribution, keeping in mind the paramount necessity of low cost The application of such methods in practice must be worked out to suit local conditions and practices

Hygienic aspects

The need for scrupulous cleanliness in handling milk has already been stressed In the distribution of milk however, gross carelessness and ignorance is frequently observed Milk containers are left open to flies and dust The measuring vessels are without handles, and after use are allowed to stand in a pool of milk drippings until again required The quality of the milk is judged by dipping the fingers into the vessel and allowing the milk to run back into the bulk These and other similar practices are common, and undoubtedly lead to serious contamination with a resultant decrease in keeping quality This probably accounts for the prevalent habit of allowing milk to simmer until sold

The present tendency is to advocate the introduction of modern Western methods, such as pasteurisation and bottling, as the ideal method of milk distribution I do not consider that such methods

(11) It was stated by one manufacturer that 2 lb of 'dry ice' was sufficient to keep one maund (80 lb) of milk cold for 24 hours

will be capable of attainment in India for very many years. I am indeed doubtful whether, in view of the dietary habits of the Indian population, they are called for at all. But in any event it is, I believe, fundamentally unsound to endeavour to replace the present crude and primitive methods of distribution by the most modern processes which have only been introduced into wealthy countries like Great Britain and the United States within the last thirty years. It is no use trying to teach the Indian dairy industry to run before it can walk.

For the mass of the population some form of 'loose' milk distribution appears to be inevitable. The 'loose' delivery of milk has been condemned in Western countries on account of the risks of spreading milk-borne disease(12). It has already been pointed out that this argument does not hold for India. The problem in India is, therefore, to devise a cheap method of 'loose' milk delivery which, while not perhaps attaining an ideal standard of hygiene, will eliminate gross forms of contamination. For this purpose one might, I think, take as a model the methods and utensils almost universally employed in Great Britain about thirty years ago and still found in common use in the smaller country towns and villages(13).

The possibility of applying such methods of milk distribution under Indian conditions would need to be investigated by carefully controlled experiments, and modifications would probably require to be introduced to meet local circumstances. Here, as in the problems of milk production, much work of an apparently elementary nature needs to be done. But until cheap and satisfactory methods have been worked out and tested under practical conditions I do not think that any improvement in existing methods of distribution can be looked for.

A short reference should, perhaps, be made to the 'itinerant' cow, *i.e.*, the animal which is taken from door to door and milked in the customer's presence. In theory this method has two great advantages. The milk is always delivered fresh, and the milking of the animal in the presence of the customer checks adulteration. In practice the method is, however, open to serious objection. It entails the housing of cattle in urban areas, which is undesirable on public

(12) E. F. Brown and Leland Spencer. "Is Loose Milk a Health Hazard?" New York City Milk Commission, 1931.

(13) This consists essentially of using a milk can with a wide mouth, for ease of cleaning; a hinged lid which protects the milk during transit and which cannot be removed and placed on a dirty and contaminated surface while milk is withdrawn from the can; and internal metal bands on which the handles of the measuring vessels may be hung, again preventing external contamination from spilled milk or flies. Such a milk can may be purchased comparatively cheaply, *i.e.*, from Rs. 5 to Rs. 10. I do not favour the use of taps under Indian conditions. They are difficult to clean and sterilise, and do not overcome the difficulties involved in the contamination of measuring vessels. Moreover the fat of Indian cows' and buffaloes' milk tends to rise to the surface very quickly, so that milk drawn off from a tap is liable to have a low fat content. In the simpler type of can the measuring vessel (which is invariably provided with a handle) may be used to stir the milk and this ensures a uniform distribution of fat throughout the bulk. The can and measuring vessel can be readily sterilised in scalding water.

health grounds It is questionable whether milk production and distribution under such conditions is economic The practice has all the disadvantages of the 'city stable' system without the advantage of centralisation—i e, reduced labour costs, the purchase of foodstuffs in bulk, etc And finally, since the greater part of the milk fat is contained in the 'strippings' the customer is apt to be defrauded of a valuable part of the milk[14]

The second essential in milk distribution is to ensure the purity of the milk, by which I mean the absence of adulteration It is, I think, universally recognised that the prevalence of adulteration constitutes one of the most urgent and difficult problems of milk distribution Table 12 shows the collected figures relating to the adulteration of milk samples examined by provincial authorities[15] It will be seen that from 19 to 66 per cent of sample were adulterated There is, moreover, no indication that the number of adulterated samples is decreasing The mean amount of water added is difficult to assess but Table 13 probably provides a fairly representative example of the figures generally obtained in analytical laboratories[16] Apart from the detrimental reaction of adulteration on the sale of milk through distrust on the part of the consumer, this practice has the virtual effect of reducing the market for milk, since for every unit of water added an equivalent quantity of milk fails to be sold Assuming that milk is on the average, adulterated to the extent of 10 per cent of added water, the financial loss to the dairy industry amounts to over 10 crores of rupees[17] This is perhaps, an over estimate, since adulteration is partly practised in order to enable the seller to reduce the price of milk and thus increase his sales It is, however, sufficient to indicate the magnitude of the issues involved What can be done to remedy the position ?

The prevention of adulteration.

One of the predisposing causes of adulteration has already been mentioned, namely the necessity of keeping the price of milk within the purchasing power of the consumer It is obvious that unless milk distribution can be put on to a paying basis adulteration is inevitable This subject will be dealt with in a later chapter and in Appendix II But apart from adulteration due to such economic difficulties, there is no doubt that wilful dishonesty plays a considerable part in the matter and so long as the dishonest vendor can increase his profit without any serious risk of prosecution or punishment, the practice of adulteration will increase In this connexion I should point out that appropriate legislation exists in practically all municipalities by which convicted persons can be punished The difficulty is that this legislation is not applied effectively Offenders are frequently not prosecuted, and if prosecuted the fine imposed is quite insufficient to act as a deterrent Such a position cannot be

(14) Z R Kothavalla and co workers "An Investigation into the Variation of Fat and Solids not fat in cows' milk drawn at different times during the Process of Milking" *Journ Cent Bur Animal Husb and Dairying*, 3, 122 (1930)

(15) Figures obtained from the Public Health Commissioner, New Delhi.

(16) Figures obtained from the Provincial Marketing Officer, Bengal.

(17) Namely 10 per cent of 107 crores of rupees (see Table 10)

dealt with by recommendations of a technical character and lies out side the scope of my report.

It is, however, legitimate for me to indicate the lines along whic' improvements might be effected in certain technical aspects of adul teration. In the first place it is necessary to have reliable method for the detection of adulteration. For this purpose it is essen i·l that standardised apparatus and tests should be employed. At nc centre did I find standardised apparatus in use. Yet considerable errors may be made through the employment of, for example, unstandardised butyrometers and lactometers. Specifications are now available for standardising these instruments(19), and it should be made obligatory to use apparatus of approved design in carrying out all official tests. Further, existing conversion tables for the determination of total solids in milk are based on the milk of European breeds. It is essential that similar tables should be worked out for milk derived from Indian breeds of cattle and from buffaloes.

Milk standards.

In the second place, attention should be given to the actual standards laid down in milk legislation. These have been formulated without a sufficient basis of fact, and, moreover, show a serious lack of uniformity throughout India. The Imperial Council of Agricultural Research are endeavouring to remedy this position by formulating a set of standard regulations which might be adopted by provincial governments and municipalities. I consider that this is a most useful contribution to the problem. I feel, however, that further information is required on certain aspects of the subject before any final recommendations can be drafted.

Standards for milk may be based on one of two methods. An arbitrary standard may be laid down to which all milk must conform. Alternatively milk may be legally defined as the unaltered lacteal secretion of the cow. In practice these two standards may be combined, as, for example, in Great Britain where there are 'presumptive' standards below which milk is presumed to have been adulterated.

The difficulty of accepting an arbitrary standard is that it takes no account of the normal day-to-day variations in the composition of milk nor of the fact that the quality of milk secreted by different animals of the same breed may vary. It has, for example, been shown in Great Britain that the frequency with which a bulk sample of milk falls below the presumptive standards of 3 per cent. fat and 8.5 per cent. solids-not-fat depends on the number of cows in the

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(19) "British Standard Apparatus and Methods for Determining the Percentage of Fat in Milk and Milk Products by the Gerber Method. Part I, Apparatus; Part II, Methods"; "British Standard Specification for Density Hydrometers for use in Milk"; and "British Standard Specification for Floating Dairy Thermometers." Published by the British Standards Institution, London, as Bulletins 695, 696 (Parts I and II) and 734.

herd[20] With a large herd the mixing of milk from a number of cows tends to even out any abnormally high or low values, so that the average values for the mixed milk tend to fall slightly above the presumptive standards With a small herd, on the other hand, one or two animals which give abnormally high or abnormally low values will seriously affect the average values for the milk In spite of the fact that such milk is genuine, it may frequently fall below the presumptive standards This point is of particular significance under Indian conditions, where milk is frequently derived from a very small group of animals The only known method of overcoming this difficulty is to use the so called " freezing point " method of testing the milk This test is almost infallible as an index of the genuineness of milk The present " freezing point " values have however, only been worked out for European breeds and the method would therefore have to be tried out extensively on the milk of Indian cattle and buffaloes before it could be applied to Indian conditions[21]

One further point might be mentioned At present there are dual or even triple standards for milk, corresponding to the average composition of cows' milk, buffaloes' milk, and mixed milk This I am informed, leads to considerable difficulties in the detection and prevention of adulteration An alternative would be to fix a single standard for all types of milk This would of course need to be a relatively low standard, and would enable milk of high fat content to be ' toned ' with separated milk Separated milk is of great value as a supplement to the Indian dietary on account of its high content of ' first class ' protein and mineral constituents It may too be noted that in their recommendations, the Technical Nutrition Committee of the League of Nations[22] suggest that 3 0 to 3 5 per cent is the optimum fat content of milk so far as nutritional requirements are concerned Moreover the ' toning ' of milk with separated milk has none of the disadvantages of adulteration with water since the nutritional value is not reduced while the cost of milk would be cheapened It has been objected that the Indian population favour a high fat content in milk but I understand that this is largely due to the fact that many families make *ghee* in the home because they cannot purchase unadulterated *ghee* in the market If *ghee* adulteration could be prevented, and a product of guaranteed purity could be placed on the market the need for liquid milk of high fat content would disappear The provision of a single standard for milk might be open to abuse but, in view of the high nutritional value and the cheapness of ' standardised ' or ' toned ' milk, the suggestion does I believe warrant careful consideration

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(20) J F Tocher " Variations in the Composition of Milk ' H M Stationery Office, Edinburgh (1925)

(21) It has been objected that determinations of the " freezing point " present special difficulties owing to high atmospheric temperatures and the consequent difficulty of using ether Such difficulties should not be insuperable, especially in view of the increasing availability of ' dry ice '

(22) " The Problem of Nutrition Volume II Report on the Physiological Bases of Nutrition " (League of Nations Publication 1936)

CHAPTER IV.—The Manufacture of Butter and Ghee.

Relative importance of butter and ghee.

It has been pointed out that the manufacture of *ghee* is of special importance in Indian dairying economy, since this product leaves the greater and most valuable part of the milk—the non-fatty solids contained in the *lassi* (or butter-milk)—for the use of the cultivator and his family. This also applies to the production of 'country' butter. 'Creamery' butter leaves separated milk as a by-product, but under present conditions most of this is utilised in the manufacture of casein, and is thus lost as a nutrient.

Since *ghee* making leaves the greater part of the milk with the cultivator it cannot be expected to yield an economic return. Valued at, say, 9 annas per lb.(1), *ghee* gives a cash return of Rs. 3-6-0 per 100 lb. of milk, while the same quantity of milk sold liquid at 1 anna per lb.(1) would give Rs. 6-4-0, or roughly twice the sum realised for *ghee*. Yet far more milk is utilised for *ghee* manufacture than is sold for liquid consumption (Table 2). This is, of course, partly due to the fact that cultivators situated in areas remote from towns cannot market their milk in a raw state, though this market is in any event very limited. It is also partly due to the fact that *ghee* production meets the special needs of the cultivator, since it provides him with a cash sale, in addition to leaving him the *lassi*.

Compared with *ghee*, the output of both 'country' and 'creamery' butter is very small, as shown by the following figures.

Product.	Quantity of milk used in production (maunds).	Percentage of total production.
Ghee	363,700,000	97·2%
'Country' butter	9,036,000	2·5%
'Creamery' butter	1,304,000	0·3%

Moreover 'country' butter is chiefly used for the home production of *ghee* (in order to avoid purchasing an adulterated product), so that the use of butter *per se* is almost negligible.

In the present chapter I shall deal mainly with the production and marketing of 'country' butter and *ghee*. A short account of the production and marketing of 'creamery' butter will, however, also be included.

Production of 'country' butter.

As 'country' butter is invariably an intermediate product in the manufacture of *ghee* it will be best to deal first with its production and properties. 'Country' butter is most commonly obtained by churning whole milk which has been allowed to sour, usually after addition of 'starter' from the previous day's batch. The

(1) Retail prices.

soured milk or *dahi* is broken up and poured into the vessel in which it is to be churned, additional water being added if necessary to reduce the consistency of the mass The milk is churned with a rotating wooden pole to which beaters are attached, this pole being rotated by a small piece of rope which is twisted round it and pulled alternatively backwards and forwards After 15 to 20 minutes the *dahi* starts ' breaking ', and water is added to assist the separation of fat, which rises to the top of the mass in the form of grains This is usually over churned to collect it into lumps Excess butter-milk is pressed out by hand The daily outputs of butter are allowed to accumulate over several days before sale or conversion into *ghee*

' Country ' butter is invariably colourless Owing to the fact that it cannot be collected into grains it is never washed during manufacture, and it consequently contains a relatively large proportion of casein, and is greasy in appearance It has an acid taste and aroma, the acidity increasing with the period of storage

Since ' country ' butter is an intermediate product in the manufacture of *ghee,* the question whether it is worth while to try to improve its production must depend on whether such improvement will favourably affect the quality of the *ghee*

Production of ghee

Ghee itself is essentially clarified butter fat It may be produced from ' country ' or from ' creamery ' butter The latter is a relatively common procedure in certain districts of North Bihar, where mechanical cream separators have been extensively installed The butter is boiled over a medium but steady fire, being stirred until the mass is melted After boiling for some time a muddy coloured scum gathers on the surface and is removed with a perforated ladle The effervescence gradually diminishes as the moisture content is reduced while particles of curd (casein) are seen to rise and circulate from the bottom of the pan At this stage a characteristic aroma is noticeable and this is an indication that the *ghee* has been sufficiently heated After settling and cooling for some hours the *ghee* is removed to separate containers (either to small earthern pots or kerosene tins) for sale The casein residue is found as a semi-solid mass at the bottom of the pan, and represents about 0 5 per cent of the *ghee*

For large supplies of *ghee* (for example, to meet army requirements) the product may need to be refined and blended This is carried out by testing individual consignments of *ghee,* deciding the proportions of each necessary for the required blend, and then mixing the bulk in heating tanks The reheating not only enables blending to be effected but assists in the refining process the mixed product being re filtered before packing for storage or distribution

Ghee is judged partly by its appearance and texture and partly by its taste and aroma It should have a slight yellowish colour It should have a fine granular texture and should be neither greasy

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'Country' butter is invariably colourless   Owing to the fact that it cannot be collected into grains it is never washed during manufacture, and it consequently contains a relatively large proportion of casein, and is greasy in appearance   It has an acid taste and aroma, the acidity increasing with the period of storage

Since 'country' butter is an intermediate product in the manufacture of *ghee,* the question whether it is worth while to try to improve its production must depend on whether such improvement will favourably affect the quality of the *ghee*

Production of ghee

Ghee itself is essentially clarified butter fat   It may be produced from 'country' or from 'creamery' butter   The latter is a relatively common procedure in certain districts of North Bihar, where mechanical cream separators have been extensively installed   The butter is boiled over a medium but steady fire, being stirred until the mass is melted   After boiling for some time a muddy coloured scum gathers on the surface and is removed with a perforated ladle   The effervescence gradually diminishes as the moisture content is reduced while particles of curd (casein) are seen to rise and circulate from the bottom of the pan   At this stage a characteristic aroma is noticeable and this is an indication that the *ghee* has been sufficiently heated   After settling and cooling for some hours the *ghee* is removed to separate containers (either to small earthern pots or kerosene tins) for sale   The casein residue is found as a semi-solid mass at the bottom of the pan, and represents about 0 5 per cent of the *ghee*

For large supplies of *ghee* (for example, to meet army requirements) the product may need to be refined and blended   This is carried out by testing individual consignments of *ghee,* deciding the proportions of each necessary for the required blend, and then mixing the bulk in heating tanks   The reheating not only enables blending to be effected but assists in the refining process the mixed product being re filtered before packing for storage or distribution

Ghee is judged partly by its appearance and texture and partly by its taste and aroma   It should have a slight yellowish colour   It should have a fine granular texture and should be neither greasy

nor waxy. The aroma of well made *ghee* is typical and its taste slightly acid. There should be no taints or abnormal flavours.

I have felt that it was desirable to include this short account of the production and properties of *ghee* before dealing in detail with possible methods for improving its manufacture and quality.

The out-turn and quality of ghee.

In the country method of production up to 10 or 15 per cent. of fat may be lost although such fat is, of course, actually retained in the *lassi* and consumed by the cultivator's family. But this involves an equivalent loss of cash returns from the *ghee*, an important item for the cultivator. The first direction in which improvement might be effected is, therefore, in the total out-turn. It has been suggested that the use of the cream separator will result in a greater out-turn per unit of milk. Two sets of workers claim to have obtained increased yields by the use of separators and of modern methods of churning([2]). In neither instance, however, are the results based on a sufficient number of tests to justify the authors' conclusions. A method based on an entirely new principle, that of separating the milk, re-separating the diluted cream, and making the *ghee* direct from the re-separated product (*i.e.*, omitting the intermediate step of butter-making) has been published recently([3]) and is under test at the Imperial Dairy Institute. Both these methods have, however, the disadvantage that the by-product from manufacture is separated milk and not *lassi*. I am informed that the Indian villager prefers the latter as a beverage, although this may only be the result of a very conservative taste. The difficulty might be overcome by making a skim-milk *dahi* from the separated milk.

A more fundamental difficulty is involved in the relation between total out-turn and quality. It is essential that quality should not be sacrificed in efforts to obtain higher yields of *ghee*, for this would merely result in a lowered market value for the product. Experienced merchants state that *ghee* made by the 'separator' method is inferior in quality to *ghee* made by the 'country' process, and that the souring of milk in the latter process imparts a particularly acceptable flavour. Only one series of well-controlled experiments can be found in the literature on the subject([4]), and the report of this series bears out the above contention, the authors stating that "the distinctive aroma was present only in the *ghee* prepared from *dahi* (soured milk)". The same authors obtained a larger out-turn of *ghee* from sour than from fresh milk. It might also be

([2]) A. K. Y. Narayan Aiyer. "Methods of Butter-making Local and Improved." Dept. of Agriculture. Mysore State. Bull. 9 (1916) ; Z. R. Kothavalla and S. Cox. "Results of the Experiment in *Ghee* making by the Country and Separator Methods." *Journ. Cent. Bur. Animal Husbandry and Dairying*, **1**, 95 (1927).

([3]) M. F. French. "Some observations on the Methods of making Clarified Butter (*Ghee*) with some Notes on a new Method." *Bull. Imp. Inst.* **34**, 33 (1936).

([4]) A. D. Stewart and N. L. Banerjee. "Some observations on the progress of making *Ghee*, and its effect on the Legal Standards." (1929).

mentioned that the use of the 'country' method has one other advantage, in that the *dahi* does not deteriorate if churning has to be unduly delayed Elasticity in point of time is a valuable factor in fitting the method into the programme of agricultural operations, which sometimes occupies the entire time of the cultivator and his family

It is apparent that the whole subject of the relation of the out turn and quality of *ghee* to the method of manufacture requires thorough re investigation Such investigation should be carried out on an adequate scale and as far as possible, with methods of control of quality based on objective tests

Factors affecting quality

This raises a further point of great importance in relation to *ghee* making At present no information is available regarding the factors concerned in the quality of *ghee* whether, for example, the flavour is dependent on the free acid content on an incipient break down of fat constituents through bacterial action or heating or on other factors not directly concerned with the fat constituents It is interesting to find that the army requirements (so far as quality is concerned) are based on the acidity of *ghee,* the standard value being under 9 points(5), *ghee* with an acidity between 9 and 11 points being accepted for blending, and *ghee* having an acidity in excess of the latter value being rejected Table 14 shows the results obtained with a series of samples tested during 1935 36 It will be seen that the greatest number of samples had acidities of between 7 and 9 points and it may be taken that this represents typical results for a *ghee* of a very good quality It is instructive to note that the acidity of 'creamery' butter should not exceed 3 to 4 points, a value given by only 3 per cent of the samples of *ghee* This may perhaps account for the disfavour in which *ghee* produced from creamery butter is held by experts

It is almost certain that the greater part of the acidity of *ghee* is developed during the initial souring of the milk and the storage of 'country' butter prior to *ghee* making It is however interesting to find that the acidity of *ghee* itself increases during storage in spite of the low moisture content of the product Figures obtained from the Military Food Laboratory Kasauli show that *ghee* may increase in acidity by as much as 7 points over a period of two years' storage the increase being more rapid in the hot weather than at other periods of the year

Another point of importance in relation to the production of *ghee* is the seasonal variation in the quality of the product It is stated that the best *ghee* is produced between November and March, and that *ghee* produced during the monsoon period is of definitely inferior quality Again most *ghee* is of mixed origin in that it is derived from the butter fat of both cows and buffaloes but distinct local preferences exist for *ghee* in which the fat of one or the other

(5) A 'point of acidity means the amount of acid reckoned as oleic acid contained in 10 grams of a sample of *ghee* which is exactly neutralised by tenth normal sodium hydroxide This is 0 282 per cent

predominates. Neither of these points has, so far as I can ascertain, been investigated in any detail, although the implications are of considerable economic importance.

This general discussion serves to illustrate the very large field open for useful investigation. The effect of process of manufacture, of temperature, of heating, of season of the year and of conditions of storage on the out-turn and quality of *ghee*, and the chemical and physical factors affecting flavour, palatability, and texture (a question which I have not dealt with) are all practically unexplored subjects. Moreover it is on such investigations that any future improvements in technique and methods must ultimately be based. I consider that the importance of *ghee* in the dairy economy of the country justifies extensive study of the many problems connected with its production and properties. I suggest that in any such study, the co-operation of the Military Food Laboratory, Kasauli, should be sought, since this institution has had a unique opportunity of investigating methods of control of *ghee* quality.

The adulteration of ghee.

Any attempts to improve the quality of *ghee* will be largely abortive unless adulteration with cheaper and inferior fats can be checked. Constant statements were made to me that it is practically impossible to purchase unadulterated *ghee* on the open market. Official figures lend support to this view. It will be seen from Table 15 that from 7 to 65 per cent. of officially examined samples are classed as adulterated. This table shows, moreover, that adulteration is not being checked ; in several instances it appears in fact to be on the increase.

There are no figures available which provide any estimate of the average amounts of adulterant added to *ghee*. The chief fats used are *banaspatine*(6), *charbini*(7) and certain pure vegetable oils such as groundnut oil, coconut oil, and cottonseed oil. A very rough estimate of the quantities of adulterants used may be obtained from figures relating to the quantities of these products available in India. *Banaspatine* is produced at five factories. The potential capacity of these factories is stated to be 33,000 tons per year but the present output probably does not exceed 25,000 tons. In addition to this about 1,000 tons are imported from foreign sources. It is the opinion of some of the manufactures that about 90 per cent. of the total supplies (or 23,500 tons) are used for the adulteration of *ghee*. As regards *charbini*, no direct estimates are available, but an indirect calculation from the figures for the annual productions of hides in India(8) indicates that there would be available at least 11,000 tons

(6) Under the Punjab Pure Food Act, 1929, *banaspatine* means any article of food, whether mixed with *ghee* or not, which resembles *ghee*, but is derived from vegetable fat and contains no animal fat other than milk fat. It is usually referred to as *vegetable ghee*, and consists largely of hydrogenated vegetable oils.

(7) Under the Punjab Food Act, 1929, *charbini* means any article of food, whether mixed with *ghee* or not, which resembles *ghee* or *banaspatine*, but contains animal fat other than milk fat.

(8) Figures taken from the Hide Cess Enquiry Committee's Report, 1930.

of *charbim* per year Figures for the production of other Indian vegetable oils available for the adulteration of *ghee* cannot be gauged with any accuracy At a very rough estimate one might perhaps place this quantity at 15,000 tons This would bring the total amount of available adulterants to just under 50,000 tons, or 1,400,000 maunds The annual production of *ghee* is estimated at 23,000,000 maunds The amount of adulterant available would thus work out at just over 6 per cent of the total out put of *ghee* At a retail price of Rs 32 per maund, the amount of genuine *ghee* replaced by adulterant would represent over 3 crores of rupees It is probable, in view of the results of analyses already referred to, that this greatly underestimates the loss to the dairy industry as a result of the adulteration of *ghee* If adulteration could be checked this additional income could be added to the wealth of the countryside, with consequent advantage to the rural population It may be mentioned that *banaspatine* can be purchased at from Rs 10 to Rs 12 per maund and *charbim* at from Rs 6 to Rs 12 per maund, as compared with Rs 25 to Rs 40 per maund for *ghee* Adulteration is therefore a very paying proposition for the dishonest merchant

As with the adulteration of liquid milk, part of the difficulty in checking adulteration is due to lax administration of the law, a subject which I have dealt with in the previous chapter But the absence of quick and reliable methods of detecting adulteration is also partly responsible for this widespread practice A brief discussion of this latter aspect of the problem is therefore desirable

Detection of adulteration

The present official standards for *ghee* are based on the refractive index and the Reichert Meissl value, the latter giving a measure of the volatile fatty acids present in the fat. The actual standards vary somewhat from province to province In the Punjab and in Bengal the refractive index[9] is fixed at 40 to 42 5 in Bihar and Orissa at 40 to 42 and in the Central Provinces at 40 to 46 The standard Reichert Meissl values are between 24 to 32 for the Punjab *and between 19 to 36 for the Central Provinces* *In Madras Presidency* the value may not fall below 20 and in Bengal below 24, while in Bihar and Orissa there are separate minimum values for *ghee* produced from cows' milk (*i e*, 24), buffaloes' milk (*i e*, 30) and mixed milk (*i e* 28) The latter value corresponds with the army specification It may be mentioned that the common adulterants have low Reichert Meissl values but variable refractive indices, animal fats having higher and coconut oil lower values than those of genuine *ghee* It will be instructive to examine typical figures for *ghee* given by different authorities As regards refractive index, workers at the Imperial Dairy Institute[10] have given values for 11 samples of village produced *ghee* from 42 8 to 43 4 The extreme values recorded for *ghee* produced from the milk of individual breeds

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(9) *Expressed throughout as butyro refractometer readings at 40°C*

(10) S D Sunawala and Z R Kothavala. "Study of the Various Standards adopted for the Examination of Indian Butter and *Ghee*" *Agric and Live stock in India*, 5, 480 (1935)

were 43.0 and 45.1. No consistent differences were observed between *ghee* obtained from cows' and from buffaloes' milk. These workers suggest that the standard should be fixed at 42.0 to 45.5. The army authorities specify extreme values for genuine *ghee* as being 40.0 to 42.5(11). A third group of workers(12) find values varying between 40 and 44, the majority of samples falling between 42 and 43. The frequency distributions of these various values are shown in Table 16. Similar differences are found in the Reichert-Meissl values recorded by these three authorities. Such differences are, perhaps, attributable to the fact that the Reichert-Meissl value of the fat of cows' milk differs from that of buffaloes' milk, the former having a value of about 26 to 28 and the latter of well over 30. This difference is shown clearly in Table 16. The first group of workers were dealing with specially prepared samples of cows' and buffaloes' *ghee*, with the consequence that the results show two maxima. The second group were handling *ghee* which was chiefly obtained from Indian States on the western borders of the United Provinces, where buffaloes predominate. The third group probably obtained their samples from the eastern section of the United Provinces, and from Bihar, where cows tend to predominate. This explanation does not, however, account for the marked differences in the ranges of refractive indices observed by the three sets of workers.

This discussion is sufficient to show that even in the two tests normally used as standards there are considerable differences of opinion regarding the range of values of genuine samples of *ghee*. Variations due to local differences of climate and fodder, to season of the year, and to method of manufacture and storage have not been studied in any detail. Nor have other supplementary tests been fully investigated. In this connexion it may be mentioned that the need for a quick and simple method of determining adulteration will become urgent if proposals for the grading and improved marketing of *ghee* materialise at an early date. At present I understand that private merchants are charged exorbitant fees if they obtain the assistance of official analysts in the examination of their *ghee*, while the length of time taken for such examination makes purchase on a quality basis almost impossible(13). I consider, therefore, that, in view of the important issues involved, special attention should be given to the re-investigation of methods of analysis of *ghee* and to the formulation of standards suitable for use in various parts of India.

Sale of banaspatine.

Any discussion of the adulteration of *ghee* would be incomplete without reference to the conditions of sale of *banaspatine*. Although this product is largely used as an adulterant of pure *ghee*, it is also on sale under the name of 'vegetable *ghee*' or even as '*ghee*'. As a cheap source

(11) Figures obtained from the Military Food Laboratory, Kasauli.

(12) N. N. Godbole and Sadgopal. "Butter-fat Composition, Nutritive Value, etc." Benares Hindu University, 1930.

(13) It is stated to be not uncommon to have to pay a fee of Rs. 16 per sample, while analysis may involve a delay of 7 to 14 days.

of fat this product cannot be objected to, the case is equivalent to that found in Western countries, where butter and margarine are both marketed The objection arises when the vegetable product is used to adulterate the genuine one, or when it is sold under a name (such as vegetable butter or vegetable *ghee*) which is apt to deceive the customer as to its real origin and composition In Western countries the latter difficulty has been met by providing legislation which prevents misrepresentation Thus under the Food and Drugs (Adulteration) Act, 1928, it is specifically laid down in regard to margarine that "the Minister shall not approve any name .. if it refers to or is anything connected with the dairy interest", while every package containing margarine must be distinctively labelled(14) This enactment has been most effective in preventing vendors from selling vegetable fat substitutes or butter mixtures as dairy products I suggest that similar legislation regarding *ghee* and its vegetable substitutes would prove of great value in meeting the present difficulties of vendors of genuine *ghee* Such legislation might also include regulations for the registration of *banaspatine* factories and of all consignments of this product(15)

Even if *ghee* of better quality and of guaranteed purity can be produced it will still be necessary to develop improved marketing facilities At present the *ghee* producer is handicapped in two directions Firstly, he is frequently out of reach of a convenient market at which he can dispose of his produce(16) The consequence is that he either has to store his output for prolonged periods, with consequent lowering of quality, or he has to deal through middlemen who fail to give him a fair price and who frequently adulterate the *ghee* in order to increase their profits or reduce their prices It is clearly desirable that additional markets should be established so that every *ghee* producing area is adequately provided for

The marketing of ghee

Secondly, the producer has no means of getting his *ghee* graded and tested for purity, so that whether the quality is good or bad, whether it is adulterated or pure, he still tends to receive the same price Under such circumstances there is no encouragement to produce a better article

It appears therefore that the establishment of *ghee* grading centres is urgently called for Legislation is now available(17) under which Government can prescribe official standards for the grading of certain classes of produce, among which are included milk products I do not consider, however, that grading alone would

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(14) 18 and 19 Geo 5 Ch 31, Sections 6 and 23

(15) *Ibid*, Sections 8 and 9 It has been suggested that the use of *banaspatine* as an adulterant of genuine *ghee* might be prevented by making it obligatory to colour the former with an easily recognisable dye I do not consider this to be either feasible or desirable

(16) Instances were quoted to me of producers who were more than 100 miles from the nearest market.

(17) Agricultural Produce (Grading and Marking) Act, 1937

prove effective; it would probably be necessary to encourage the establishment of blending and packing stations, perhaps on the lines of the Military *Ghee* Heating Centre at Agra. Such stations might be organised on a co-operative basis, by private individuals or by Government itself. Co-operative efforts have already been made in this direction, notably in the United Provinces where several *Ghee* Merchants' Associations have been formed. But the present organisations hardly go far enough in the direction of grading and of blending, nor are the results of the laboratory tests always trustworthy. In such developments it is essential that Government should take the lead and should itself provide facilities for the testing and grading of the *ghee*.

It has already been stated that the establishment of grading stations will necessitate the development of quicker and cheaper tests for adulteration and quality. Another direction in which investigation is desirable is in the methods of packing *ghee*. For relatively large quantities the existing tin containers are quite suitable, though methods would need to be devised for closing these containers in such a way that they could not be tampered with after being graded(18). But for smaller quantities it would be advantageous to have small non-metal containers which would prevent contamination during handling and would effectively check adulteration by the shop-keeper.

One further point. It was remarkable to find that *ghee* is seldom if ever advertised in India. This is probably due to the poor and variable quality of the produce and to the absence of any proprietary brands. If grading and marketing schemes are to be successfully established it is, I believe, essential that they should be supplemented by adequate advertisement. It was significant to find that a single firm of importers of condensed and dried milk products spent Rs. 2 lakhs a year on advertisement, although the sale of their products would represent only a minute fraction of the value of the *ghee* at present produced in India. A relatively uneducated population is particularly susceptible to propaganda. The value of advertisement as a means of popularising the improved grades of *ghee* should not therefore be neglected in any future marketing developments.

The export market for ghee.

During the years 1924 to 1929 *ghee* amounting to roughly 38,000 cwt. (53,000 maunds) was sold for export from India(19). Between 1929 and 1935 there was, however, a fall of over 33 per cent. in the quantity exported. At the same time the value per maund of *ghee* fell from Rs. 70 to Rs. 41. The total value of the exported *ghee* showed therefore an even greater fall, from Rs. 38 lakhs to Rs. 14 lakhs, or 63 per cent. (Table 17). The quantities exported are, of course, very small in comparison with India's total output of

(18) Several methods have been tried out in the United Provinces in connexion with the sale of *ghee* under private trade marks.

(19) Annual Statements of Sea-borne Trade of British India.

ghee, which amounts to about 23 million maunds It has been suggested, however, that this fall in exports is due to a deterioration in the quality of the *ghee* produced in India As this is a point of considerable importance in relation to the foregoing discussion, it seemed desirable to obtain further evidence on the point Figures were therefore obtained regarding the imports of *ghee* into Malaya, which is India's chief customer[20] These figures are also shown in Table 17 It will be seen that, while India's total exports decreased by roughly 33 per cent between 1928 and 1935, Malaya's total imports fell by over 50 per cent during the same period The percentage of Malaya's *ghee* imported from India remained substantially constant at about 95 per cent It is apparent, therefore, that India not only held her own in the Malaya market, but was able to find additional markets in other countries during this difficult period These facts do not bear out the suggestion that deterioration in the quality of Indian *ghee* is affecting the export trade the decrease in the latter is a result of general world depression in trade In this connexion the following official comment regarding Malaya's reduced imports of *ghee* are significant[21] — Probably this is partly due to the extensive repatriation of Indian immigrant labourers which occurred as a result of the slump, and to decreased purchasing power of those who were left I should imagine that the 1936 figures would show a rise with the partial return of prosperity and the resumption of immigration The position may, however, also be affected to some extent by the drive which has been in progress to popularise locally produced fats, notably coconut oil, in place of imported fats " This comment affords both encouragement and warning encouragement, in that it implies a possible re opening of India's export trade in *ghee*, and warning, in that it indicates the increasingly serious competition of vegetable oil substitutes It re emphasises the need not only for maintaining but for improving the quality of Indian *ghee*

The production and marketing of 'creamery' butter

It has already been stated that 'creamery' butter represents only a minute fraction of the output of Indian dairy produce being equivalent to about 0 3 per cent of the output of *ghee* or to roughly 0 15 per cent of the output of total milk products Its consumption is limited to the European population and to a small number of Indians who have acquired European tastes

There are, however, indications that the demand for 'creamery' butter is improving Imports of this product show progressive increases as is seen from Table 18[19] It might be supposed that these increases represent displacements of Indian produced butter Returns from three prominent Indian producers show, however, that while imports of butter increased by 23 per cent between 1933 and 1934, their own combined output increased during the same period by over 30 per cent Imported butter constitutes, in fact, a relative-

(20) Figures obtained through the courtesy of the Colonial Office

(21) Communication from the late Director of Agriculture in Malaya forwarded through the courtesy of the Colonial Office

ly small proportion of India's total consumption, as shown in the following table :—

Type of butter.	Quantity of milk used in production. (Maunds).	Percentage of total butter production.	Percentage of 'creamery' butter consumption.
Indian 'country' butter	9,036,000	86·0%	..
Indian 'creamery' butter	1,304,000	12·5%	89·5%
Imported 'creamery' butter	154,000	1·5%	10·5%

The development of refrigeration will probably tend to popularise still further the consumption of 'creamery' butter. While, therefore, such butter is still a dairy product of minor importance in India, the needs of this branch of the industry should not be neglected in any future scheme of development.

Indian creameries have special difficulties to contend with in producing a butter of high standard and satisfactory keeping quality. The first is to secure an adequate supply of good quality milk. The second is that manufacture has to be carried out under exceptionally warm atmospheric conditions. The third is the fact that the fat from buffaloes' milk is stated to be unsuitable for high class butter production. It is even held that Indian cows' milk is unsuitable for this purpose. In consequence of these difficulties Indian 'creamery' butter is frequently subject to a number of defects which seriously affect its sale in competition with imported butter. It is significant in this connexion that much of the Indian 'creamery' butter fails to command as high a price as the imported product.

So far as texture is concerned, Indian butter has a tendency to greasiness and frequently lacks grain. This defect is generally recognised to be due to excessive working of the butter while in a soft condition, and is consequently largely attributable to lack of proper facilities for chilling. As regards palatability, Indian butter generally lacks the flavour and aroma typical of the Western product. This may be due to a variety of causes, but it is significant that I found the use of properly cultured 'starters' to be exceptional. A third and not unusual defect is the early development of rancidity, a fault associated with bacterial and mould growth. The occurrence of this defect is not surprising in view of the very poor quality of the incoming milk and cream. It was, for example, reported from one creamery that as regards the methylene blue reduction test (a measure of the bacterial contamination of the incoming milk) "half-an-hour was the limit for the *best* milk, while some samples decolorised the solution within a few minutes". At another creamery it was stated that the incoming milk was of such poor quality that after separation the separated milk was so acid as to be only fit for casein making. Although my tour was undertaken in

the cold weather I personally saw many churns of sour milk arriving at one creamery, and of ' gassy ' cream at another

None of these defects should be incapable of remedy if the subject were to be systematically studied I found, however, an entire lack of published information on the points mentioned above There are no published records regarding the comparative values of buffaloes' and cows' milk for butter making , no controlled experiments have apparently been made to determine the influence of the quality of the incoming milk on the keeping quality of the butter, nor has the effect of high atmospheric temperature and other adverse factors been investigated I was informed that experiments had been made on the use of properly cultured ' starters ' but no published records of such experiments were available to guide creamery managers

It was suggested to me that the investigation of these problems required large scale factory equipment, and a proposal for acquiring such equipment is included in the Anand Experimental Creamery scheme The problems mentioned above can, however be more satisfactorily studied on a small (hand churn) scale The careful control necessary in experimental work makes small scale investiga tion preferable to large scale processing both on the score of expense and accuracy , the application of the findings to factory conditions is a matter involving modifications of detail and not fundamental principles In any such work it is essential to have adequate chemical and bacteriological control throughout the production and storage of experimental batches of butter

In the meantime efforts to improve the quality of the incoming milk supply by advisory work and propaganda will certainly reduce the difficulties of the butter trade Such efforts should, if possible, be accompanied by the establishment of a system of payment for milk on a quality (*i e*, cleanliness) basis If better milk could be obtained it might enable the separated milk which is formed as a by product to be converted into a more valuable product than casein so that the additional cost of payments for quality would be recovered This subject is dealt with in detail in the next chapter

Standards for butter

One further point should be mentioned It has been suggested that the time is ripe for establishing legal standards for ' creamery ' butter similar to those enforced in Western countries Such standards would include a maximum moisture content and absence of adulterants The latter subject has been dealt with in connexion with *ghee*, and need not be further discussed As regards moisture content, it is difficult to decide a suitable standard until a more thorough investigation has been made into the technique of produc tion and the keeping quality of butter under Indian conditions At present it is suggested that the Western standard of 16 per cent moisture content should be adopted, a figure which is already included in the food legislation of various provinces It is impossible to say without further investigation whether this standard is a reasonable one

It appears to me, moreover, that improvement in the quality (*i.e.*, texture and palatability) of the product is of more immediate importance than the setting up of any legal and arbitrary standard of moisture content. If a customer can purchase butter of good flavour and texture, I believe that he will be indifferent as to whether the legal standard is, for example, 16 or 18 per cent. moisture. This is particularly true of a product such as 'creamery' butter, which may be looked upon as a luxury trade. From this point of view I consider that the whole question of butter standards might better be dealt with through the institution of a grading scheme than by general legislation.

CHAPTER V—The manufacture of khoa and dahi and of other indigenous milk products

Apart from liquid milk and *ghee* the most important dairy products produced in India are *khoa, dahi* and certain other indigenous milk products The importance of these products is partly due to the extent of their production The quantity of milk utilised for their manufacture approximates 95 million maunds[1] which is more than twice that utilised for the whole of the production of manufactured milk products in Great Britain The monetary value of this output is estimated at over 80 crores of rupees (Table 3) These figures emphasise in a striking way the magnitude of the output of indigenous milk products in India The importance of these products is, however, also partly due to the high return which they give per unit of milk This fact is shown in Table 19 It illustrates a point of unique interest, since it will be seen that the manufactured products (with the exception of *ghee* and ' country butter) realise more per maund of milk than liquid milk itself This is contrary to the experience of practically all Western countries[2]

Importance of indigenous milk products

In describing the methods of preparation of these products, it will be convenient to divide them into two groups, namely, products manufactured by the partial desiccation of milk (*khoa, rabree* and *mallai*), and products resulting from the souring of milk (*dahi, channa,* and *cheese*) General problems which are more or less common to all the products will then be dealt with

Products manufactured by partial desiccation.

In the production of *khoa* and related products the keeping quality of the milk is preserved by its conversion into semi solid form, the heat and the concentration of milk constituents both tending to eliminate bacterial growth In *khoa* making the milk (usually in quantities of about 5 lb) is evaporated in a round bottomed shallow iron pan over a fairly hot and steady fire The milk is stirred continuously to prevent scorching, a special scraper being used for this purpose As the volume becomes less the stirring is increased, and the operator has to exercise skill in maintaining a uniform consistency to the mass After 15 to 20 minutes heating the mass takes on a pasty consistency At this stage the pan is removed from the fire, and the pasty mass is well worked with the flattened end of the scrapper, being spread several times in a thin layer across the bottom of the pan This gives the product a good grain When the mass can retain its own form it is considered to be ready *Khoa* is mainly used for making sweetmeats It should be white in appearance, and should have a smooth

(1) This is equivalent to 760 million gallons According to the Report of the Milk Reorganisation Commission (1936) the amount of milk utilised for the manufacture of butter, cheese, cream and condensed and dried milks in Great Britain during 1934 35 amounted to 338 million gallons

(2) For example, milk is sold wholesale for liquid consumption in Great Britain at 14*d* to 15*d* per gallon, but when used for the manufacture of milk products its average realisation value is only about 5½ *d*

texture. The taste should be sweet and wholesome, with a slight but pleasantly cooked flavour. On keeping the surface becomes yellowish and dull in appearance, while deterioration is judged by the presence of cobweb-like threads on breaking. *Khoa* itself keeps sweet for 4 to 5 days in the cold weather and 2 to 3 days in the hot weather, but the addition of sugar in the making of sweetmeats prolongs the keeping quality to 3 to 4 months.

Rabree might be described as a sweetened form of *khoa*, but its manufacture requires greater skill and it is looked upon as a great delicacy. Stirring is avoided during making, and the solids are separated from the milk by removing successive thin films of coagulated material from the surface by means of bamboo splints. These films are placed on the sides of the heated pan. When the milk has been reduced to about one-fifth of its initial volume the pan is removed from the fire and the whole mass is gently mixed, care being taken not to injure the flakes. Sugar is then added and after cooling and settling, the *rabree* is ready for sale. *Rabree*, on account of its lower temperature of manufacture and its higher moisture content, is more perishable than *khoa*. Uniform formation of flakes, uniformity of colour and freshness of taste are the main points looked for by discerning purchasers. *Khurchan* is a similar product to which arrowroot has been added during manufacture.

The third product in this group is known as *mallai*. This is a form of clotted cream which is sold and consumed unsweetened. It is usually made by simmering large quantities of milk (say, 20 lb.) until a thick layer of milk-fat and coagulated albumin forms on the surface. This is skimmed off with a flat ladle and laid aside to cool. The process is repeated twice, when most of the fat has been removed. The residue is caramelised and is not saleable as milk. *Mallai* should be smooth and white in appearance, and has a taste typical of clotted cream. It has a very limited keeping quality.

The products in this group are only produced on a large scale in Northern India, and are particularly popular in the United Provinces, the Punjab and Bombay Presidency. It has been estimated that out of every 100 maunds produced, *khoa* accounts for 85 maunds, *rabree* and *khurchan* for 10 maunds, and *malai* for 5 maunds.

Products resulting from the souring of milk.

Probably the simplest way of preserving milk for human consumption in a tropical country is to allow it to sour, since this checks putrefactive changes while giving an acid taste to the milk which is particularly refreshing in hot climates(3). *Dahi* is milk which has been soured by inoculation with a lactic acid 'starter'. The milk is usually boiled for a short while and then allowed to cool. While still luke warm a small quantity of the previous day's supply is put in, care being taken not to disturb the surface layer of fat, which gives the product a rich appearance and is used as an index of the quality of milk. After leaving for

(3) C. V. Wiser. "The Foods of a Hindu Village of North India." Bureau of Statistics and Economic Research, U. P. Bull. 2, p. 62, Allahabad, 1936.

6 to 8 hours the *dahi* is ready for sale It has already been noted that *ghee* is prepared from soured milk, so that it may be said that the production of a form of *dahi* lies at the foundation of India's *ghee* industry The residue from churning *ghee* (*lassi*) is, indeed the most common form in which milk is consumed in India *Dahi* itself is also a popular food, which is taken with rice or wheat *chappatties* either salted or with sugar It also forms the basis of a special type of *lassi* which is commonly sold in cities and is prepared by beating up the *dahi* with water and ice and adding salt or sugar to taste Good *dahi* should have a creamy and smooth surface free from bubbles, while the cut surface should be trim and free from holes—an interesting instance of a natural objection to the presence of gas producing bacteria The taste should be mild rather than sharp

Channa is a product of a very different type It is produced from boiling milk which is clotted either by the addition of sour whey or by reagents such as alum After settling the *channa* is strained off into a coarse muslin cloth, in which it is allowed to hang for draining This product is, in fact, a crude form of moist casein It is used as a basis for sweetmeats and is capable of being transported for distances up to 300 miles without deterioration It is therefore particularly suited for the poor transport conditions of Bengal, where it is chiefly produced The properties looked for are whiteness, firmness of body and a small grain, and a non acid flavour

The production of cheese in India either of Indian or European varieties, is extremely small The chief Indian cheeses are *Dacca* cheese, *Surti* cheese, and *Bandal* cheese *Dacca* cheese may be taken as typical of the small type of medium pressed cheese It is made from buffaloes' milk with the use of rennet The curd is pressed in small cane baskets with a board and stones Pressure continues for from 7 to 10 days, when the cheese is smoked with wood and cow dung smoke The cheese keeps well after smoking *Bandal* cheese is typical of the soft type of cream cheese It also is smoked, a treatment which renders it offensive to many palates *Surti* and other local types of cheese also have distinctive methods of production

Of the products in this group *dahi* is of outstanding importance for the reasons already noted It is moreover produced and used universally throughout India The production of *channa* is largely limited to Bengal and to parts of Bihar and of the United Provinces Cheese is only found as a local product and its production is noted in all Provinces as "negligible"(4) It is probable that the main requirements of cheese in India, the consumption of which is limited to Europeans, is met by imports from abroad These imports, which

(4) Reports of provincial marketing surveys It has been suggested that the low consumption of cheese is due to the fact that an animal product (rennet) is used in its production and that the use of a vegetable substitute for rennet would stimulate the demand It should however be pointed out that the eating of cheese does not fit in with the normal dietary customs of the country

are shown in Table 20([5]), give no indication of expansion, although they show a rapid recovery from the effects of the crisis,—a finding which might be expected in regard to a product which is consumed solely by the wealthier section of the population. The present annual value of imported cheese is Rs. 8 lakhs, and the amount of milk utilised in its manufacture would be about 150,000 maunds, which is equivalent to only 0.002 per cent. of India's total milk production.

The above details regarding the methods of manufacture have been given because I feel that they are essential for a proper understanding of the problems involved in the production and marketing of *khoa, dahi* and related products. No published information is available on the subject, and present methods are based on the cumulative experience of past generations.

Improvements in production and packing.

It will be realised from the foregoing description that the manufacture of indigenous milk products in India is carried out on most primitive lines. Moreover, the quantities of milk employed in the manufacture of the desiccated products (about 5 lb.) are clearly uneconomic from the point of view of both labour and fuel. There is obvious need for a careful investigation of the methods of manufacture of these products. *Khoa* offers a particularly hopeful field for study, not only because of its wide sale but because its manufacture does not involve the production of by-products. It appears possible that its manufacture could be placed on a village industry basis or even on a factory basis. The problems involved are largely engineering problems ; the provision of a plant capable of handling the larger outputs while retaining those essential heating processes which give the product its characteristic flavour. It is possible that some type of band-drier might be employed, though existing types of such plant would need very considerable modification if they were to meet the special requirements of *khoa* production. The output of the product is, however, sufficient to justify considerable outlay in determining the feasibility of such a development.

Side by side with improvements in the production of *khoa,* improved methods of packing would be needed. At present *khoa* is packed in baskets and leaves. This is unhygienic, and undoubtedly reduces the keeping quality of the product. In view of the fact that the slightly cooked flavour of *khoa* is one of its desirable characteristics it would seem that this product is one which might be packed in air-tight containers and sterilised by heat, thus giving it an indefinite keeping quality and rendering its transport simpler and cheaper. The additional cost involved would probably be offset by the decreased losses due to deterioration.

It is questionable how far *rabree* and *mallai* could be dealt with on these lines, since their manufacture is more largely dependent on the personal skill of the maker. Any develppment would have to depend on the success achieved with *khoa.* But the manufacture of

([5]) Annual Statements of Sea-borne Trade of British India.

dahi might certainly be improved At present no information is available regarding the types of lactic acid bacteria used in the production of *dahi* in different districts, nor is anything known of the relation of the types of organism to the flavour and texture of the product A survey would quickly show how far the bacterial flora varies under present conditions of production, and to what extent such variations can be correlated with palatability and market demand By subsequent distribution of the most satisfactory 'starters' the quality and uniformity of *dahi* might be substantially improved, with benefit to both producer and consumer The importance of such work in connexion with *ghee* production should not be overlooked

Possible uses for separated milk.

It will be shown in the next chapter that limited quantities of separated milk (6) are available in certain districts Such separated milk is not actually wasted, as it is largely used for the manufacture of casein It is however lost as a source of nutriment It has been suggested that efforts should be made to establish condensing and drying factories to absorb this milk, but in most localities such a development is impracticable I consider that the possibility of utilising separated milk in the manufacture of indigenous milk products would repay further investigation Such milk is already used for this purpose in some areas, but the complaint is made that the quality of the product is so inferior as to make it of little value *Khoa* made from separated milk has for example, a tougher and less acceptable texture and is apt to crumble, a criticism which also applies to *channa* On the other hand *dahi* made from separated milk lacks body It is obviously undesirable that such products should have an equal value in the market to whole milk products but there is undoubtedly room for attempting to improve the methods of production in such a way as to make the separated milk products more readily saleable

The provision of standards

The establishment of recognised standards of quality for *khoa* and related products would do much to encourage the introduction of improved methods of production and packing At present the standards (where they exist) are of doubtful utility For instance, under the Punjab Pure Food Act (1929) *khoa* must have not more than 10 per cent moisture and not less than 20 per cent fat Yet according to manufacturing practice the *khoa* out turn from milk should be 25 per cent (7) This would give *khoa* a moisture content of nearly 40 per cent The minimum fat content of such *khoa* would be 14 per cent, but the minimum fat content of a sample containing 10 per cent moisture, if made from whole milk, would be 27 per cent (8) That is to say, with a moisture content of 10 per

(6) I refer here to machine separated milk, not to *lassi*

(7) i e, 4 seers of milk yield 1 seer of *khoa* This ratio is so widely recognised that it is commonly used as a method of determining the quality of milk at wholesale milk markets

(8) Assuming the original milk to contain 3 5 per cent fat and 8 per cent solids not-fat, which are the minimum legal standards under the Punjab Pure Foot Act (1929)

cent., the fat content of *khoa* could only fall below 20 per cent. if the milk were to be 'toned' with separated milk. Clearly the existing standards need re-examination.

This introduces a further point. No provision is made in the food legislation of most provinces for standards of quality of milk products made partly or wholly from separated milk. If the proposals put forward earlier in this chapter are adopted, it will be necessary to formulate standards not only for whole milk products but for products manufactured from separated and from half-cream milk.

The nutritive value of indigenous milk products.

The final, and perhaps the most important, consideration in connection with *khoa*, *dahi*, and similar indigenous products is their nutritive value. There is at present a complete lack of information on this point. It is widely held that sour milk—either in the form of *dahi* or *lassi*—is more highly digestible and nutritious than fresh milk, and that it is particularly wholesome as a food in hot climates(3). On the other hand I have been told that the excessive heating to which milk is subjected during the manufacture of *khoa* will seriously affect its nutritive value. Neither of these views has so far been substantiated by direct experiment. The question is one of obvious importance in view of the extent to which such products constitute the staple forms in which milk is consumed by a large section of the Indian population. I am strongly of opinion that experiments should be undertaken at an early date to determine accurately the nutritive value of these various indigenous milk products in comparison with milk and separated milk. The experiments should not, I believe, be confined to laboratory animals. Comparative tests should be made into the value of the products as supplements to typical Indian diets on the lines of those already carried out with skim milk powder(9). Only by such tests will it be possible to determine the real value of the various products in the human dietary.

(9) W. R. Aykroyd and B. G. Krishnan. "The Effect of Skimmed Milk, Soya Bean and other Foods in Supplementing Typical Indian Diets". *Indian Journ. Med. Res.* 24, 4 (1937).

CHAPTER VI —The utilisation of skim milk in the manufacture of casein, condensed milk and dried milk

It is sometimes stated that there is a serious wastage of separated milk in India Another view held is that a considerable output of separated milk, while not actually wasted, is utilised in a manner which does not yield a profitable return In the present chapter I intend to discuss in detail these views and to indicate the extent to which separated milk might be more profitably handled

Present production of separated milk

By separated milk I mean the by product of the mechanical separation of cream It has already been stated (Chapter IV) that over 99 per cent of the *ghee* produced in India is manufactured by the indigenous method in which the by product is *lassi*, and that this is invariably consumed by the cultivator and his family In view of the overwhelmingly rural nature of the population this practice cannot be objected to, for it ensures that the peasant class retain for their home consumption the most valuable part of the milk This means, however, that the supplies of separated milk available for manufacture are very limited On the assumption that the daily output of creamery butter in India is 20,000 lb, the quantity of separated milk produced annually will be roughly 90 million pounds or a little over one million maunds

At present a considerable proportion of this is used for the manufacture of casein for export This export trade has remained fairly constant for the past few years at about 8 000 cwt per year The amount of separated milk required to produce this quantity of casein would be roughly 40 million pounds, or nearly half of India's total output of separated milk(1) The remaining half is stated to be used in the production of indigenous milk products such as *dahi* and in the ' toning ' of whole milk sold for liquid consumption It may, I think, be definitely asserted that the quantity of separated milk actually wasted (*i e*, thrown away) is negligible Exhaustive inquiries in the more important producing areas show that separated milk can be economically converted into casein so long as the price of the latter exceeds Rs 70 per ton During the past three years the price has averaged about Rs 260 per ton and has not fallen below Rs 117 per ton

The suggestion has, however, been put forward that since there is a valuable import trade in condensed and dried milks an effort should be made to utilise the present output of separated milk for the manufacture of these products It is therefore desirable to examine in some detail the extent of the import trade in condensed milk and milk powder These products are classed into two categories, first, milk foods for infants or invalids wholly or mainly milk, and second condensed and preserved milks The first category consists almost exclusively of proprietary brands of milk foods which it would be extremely difficult to displace with home produced products The average quantity imported during 1932 35 was 10 000

Imports of milk products

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cwt. per year, which is equivalent to about 80,000 maunds of fresh milk. In view of the special nature of this class of imports and of its small volume it does not appear either feasible or necessary to attempt to replace it with products produced in India.

The second category includes unsweetened and sweetened condensed milks, milk powder and certain other miscellaneous milk products. On the basis of replies received to a special questionnaire, the annual imports may be roughly classified under seven heads, as shown in Table 21. The total imports amount to roughly 200,000 cwt. and are valued at about Rs. 50 lakhs. They represent an output of just under 700,000 maunds of fresh milk. These quantities are very small in comparison with India's total output of milk products. Moreover, it will be seen from Table 22 that the imports (and therefor the consumption) show no tendency to expand[2]. The question arises therefore whether, if condensed milk and milk powder were to be produced in India, an additional market could be found for these products in the export market. The present imports of condensed and dried milks into Ceylon amount to 36,000 cwt., and the market is rapidly expanding[3]. Malaya imports 600,000 cwt. of condensed milk, while other Far Eastern countries absorb about an equal amount. South Africa and East Africa import some 300,000 cwt.[4]. These combined quantities (including India's own imports) represent the equivalent of roughly five million maunds of fresh milk. If Table 21 may be taken as typical of the imports of all these countries (no separate figures being available other than those for India), the amounts of whole milk and of separated milk used in the production of the milk imports would be one million and four million maunds respectively. There is therefore a fairly large potential market for condensed and dried milk, although this still represents a very small fraction of India's total output of milk. It is, of course, questionable whether, even if India was able to produce these products, she could capture the market against the keen competition of countries which already have an established export trade. The figures are, however, impressive enough to justify serious consideration of the possibility of establishing condensing and drying plants in India.

Export markets.

In deciding whether such a development is feasible, three questions must be answered. First, is the milk cheap enough ; second, can it be supplied at convenient centres in sufficiently large quantities; and third, is the milk of a sufficiently high quality to enable manufacturers to produce a good product ?

There is considerable doubt whether even the first question can be answered in the affirmative. Separated milk is valued in India at about Re. 1 per maund[5]. Assuming that the working costs of production of sweetened condensed skimmed milk are £20 per ton (a

Value of separated milk.

(2) Annual Statements of Sea-borne Trade of British India.

(3) Imports into Ceylon have increased from 17,525 cwt. in 1932 to 35,848 cwt. in 1936.

(4) *International Review of Agriculture,* June 1936.

(5) Figures obtained from Provincial Marketing Officer, Bihar.

typical British figure), a cwt of this product could be produced in India for about Rs 18 The value of the imported product is roughly Rs 28(6) per cwt, but this includes an import duty of between 20 and 30 per cent (according to country of origin) as well as heavy costs of advertising and distribution The market value of the imported product in competition with Indian export trade would be unlikely to exceed Rs 20 Again, skim milk powder can be purchased in India at Rs 36 per cwt (7) With similar working costs per ton and valuing the separated milk at Re 1 per maund skim milk powder could be produced in India at Rs 30 per cwt If the import duty is deducted from the value of the imported product however, the two prices exactly tally The above figures are admittedly approximate, but they are, I think, sufficient to show that the possibility of building up an export market for condensed milk and milk powder produced in India is open to considerable doubt On the other hand the duty of 20 to 30 per cent on products imported into India would give an Indian manufacturer a great advantage in his home market

I will now turn to the second question Can adequate quantities of separated milk be supplied at convenient centres ? The quantities required by manufacturing firms are exceptionally large Inquiries among firms already importing condensed milk and milk powder into India indicate that such quantities should not be less than 30,000 lb per day Assuming an average yield of 6 lb of milk per day per milking animal it would require 5 000 animals to produce this amount It is estimated that the average Indian village possesses some 200 to 300 milking animals A daily output of 30,000 lb would therefore require the complete milk production of some 20 villages, which might be located within a 6 to 7 mile radius of a central factory This area would in practice probably need to be larger, since part of the output of milk would presumably be retained in the villages for home consumption No information is available as to the possibility of finding areas of this character which might form suitable centres for condensing or drying factories In one or two localities, where large butter making creameries are already established, the requisite supplies of separated milk might be available But if more than one or two centres were required a detailed survey of the main milk producing areas would have to precede any question of developing production on a large scale

Feasibility of centralising supplies

This brings me to the third question Can separated milk be supplied which is of sufficiently good quality for manufacture ? At present the answer is a categorical negative Personal inquiries in likely areas and conversations with men who have been responsible for managing large butter making creameries both show that the present supply of separated milk would be entirely useless for either condensing or drying In the words of one experienced manager,

Quality of separated milk.

(6) i e, 4 annas per 1 lb tin

(7) Information obtained from Dr W R Aykroyd

"the whole difficulty is that the milk is produced on too small a scale by a very large number of producers : such small quantities could not be handled profitably if delivered direct by the producer to the creamery, while the collection of milk by middlemen results in its deterioration before arrival at the creamery...... I am firmly convinced that if any concern requires large quantities of first-class milk, it will only be possible to obtain it by organising milk production on large farms under hygienic conditions". Another equally experienced manager stated that the milk supplied to his creamery was always very acid on arrival, and that the resulting separated milk was only suitable for casein making. In his view the condensing and drying of milk would only be possible if a really good supply of milk were to be available, but that under these circumstances the cost of the milk would be prohibitive. Such authoritative opinions must carry great weight. They agree, indeed, with the experience of all those who have had to produce condensed milk and high-grade milk powder, namely, that the quality of the original milk is one of the main factors which affect the quality of the manufactured product.

Briefly then, it may be said that the manufacture of condensed milk and milk powder for export does not offer a hopeful field for development ; that such products might, however, be able to displace those at present imported into India ; but that this would depend largely on whether the requisite amounts of good quality separated milk could be collected at suitable manufacturing centres.

Technical considerations.

There are, however, a number of purely technical considerations which must be taken into account in connection with the production of condensed milk and milk powder. As regards condensed milk, the chief demand in India is for sweetened condensed skimmed milk. The production of this type of condensed milk is particularly affected by the hygienic quality of the incoming milk, since the product is not completely sterilised during manufacture. Moreover, both sweetened and unsweetened condensed milks are specially susceptible to defects associated with the protein content and the mineral balance of the milk. The methods of processing in Western countries have not only to be modified according to the locality of the factory, but also according to the season of the year. No information is available to show whether milk from Indian cows or buffaloes can be successfully condensed, or what alterations in technique might be necessary to ensure the production of a good product. It would obviously be a serious mistake to establish a condensery at a high cost until the feasibility of condensing and its major difficulties under Indian conditions have been ascertained on a small scale. It may perhaps also be mentioned at this point that the total output of condensed milk necessary to displace the imported products would not occupy more than two or three large plants of, say, 30,000 lb. capacity.

As regards milk powder, the first point to be decided is whether, in the event of its production in India, the plant used should be of a

roller or a spray drying type The former involves a very much smaller capital outlay Separated milk powder produced by the roller process is, however, very insoluble and is used in most Western countries only for the feeding of stock If the object of manufacturing milk powder in India is to produce a product for human consumption, particularly in connexion with the provision of reconstituted separated milk for children of school age, it would need to be spray dried milk This would involve a relatively high capital expenditure Moreover, milk powder production would entail special difficulties in a country having a monsoon season The combination of high atmospheric temperature and humidity during this period would necessitate an abnormally high air capacity in the drier, and might also lead to difficulties in the handling of the dried powder, which is intensely hygroscopic So far as total output is concerned, attention would need to be given to the available market From Table 21 it will be seen that the present consumption of milk powder (as measured by imports) is between 250 and 300 cwt per year A full size commercial spray drying plant will produce at least a ton of powder per day The present output in India would, therefore, only be sufficient to occupy one plant for, say, 12 to 15 days Even if a strong drive were to be made to popularise the use of separated milk powder as a supplement to the diets of school children, it is doubtful whether the output of one plant would be fully occupied An additional market might be found in the development of the ice cream trade, especially in view of the rapid extensions at present taking place in refrigeration Army requirements might also absorb part of the output of a spray-drying plant, since for transport purposes a milk powder which could be readily reconstituted in the field would be ideal The difficulty of meeting army requirements is, however, that there are such large differences between peace and war requirements Peace requirements are only one to two tons per month in time of war, however, the requirement might rise to between 100 and 200 tons(8)

Conclusions

The above discussion indicates some of the more obvious difficulties which would be met with in any attempt to establish condensed milk or milk powder factories in India The idea is superficially an attractive one, but in view of the exceptional difficulties with which the Indian dairy industry is faced, I am quite certain that any considerable expenditure (such, for example, as that envisaged in the Anand Experimental Creamery scheme) is not meantime justified If condensing and drying factories are ultimately to be built in India, they should, I believe, be erected by firms who already have a long experience of the trade and an established Indian market for their products I consider, therefore, that any official assistance which may be given should be in the direction of surveying the available supplies of milk, *examining their quality, and determining* on a small scale the suitability of the milk for processing These are the three primary requisites on which any commercial firm would need

(8) Figures quoted by the courtesy of the Quartermaster General in India

to have accurate information before giving serious consideration to the establishment of a condensing or drying factory in India.

Finally, I should once again reiterate the contention which I put forward in Chapter II, namely, that India has an essentially rural population, and that in any development of the dairy industry the needs of this section of the population must be paramount. If it was necessary to choose between establishing a factory system for converting separated milk into milk powder or leaving the separated milk in the villages for local consumption, I should unhesitatingly recommend the latter alternative.

PART II.

THE PRODUCTION OF MILK IN RELATION TO THE BREEDING AND NUTRITION OF MILCH CATTLE.

CHAPTER VII—The importance of cattle in Indian agriculture

Introduction

It will not be out of place to preface this part of the report with a brief statement of the size of the cattle industry of India and of its importance in Indian agriculture Numerically India possesses the largest cattle population of any country in the world A recent estimate(¹) places the world's cattle population at about 690 million animals Of these 152 million are located in British India and 36 million in Indian States India possesses therefore nearly one third of the world's cattle population Next in order are the Soviet Union (with 65 million) and the United States (with 58 million), but each of these has barely one third of India's total Great Britain has only seven million animals or one thirtieth of the Indian cattle population These figures indicate the magnitude of the Indian cattle industry

Owing to adverse climatic and economic conditions the productive value of this industry is not commensurate with its size It is of course difficult to assess the monetary value of live stock products in a country where the greater part of the output is consumed by producers instead of being marketed This difficulty is intensified in India where the male cattle are chiefly valuable on account of their use for draught purposes and where meat is not a staple article of the diet In the present discussion I shall deal with the subject from two aspects first, the actual value of produce derived from cattle, and second, the potential value of cattle to Indian agriculture

Income from the sale of cattle products

The income from the sale of cattle products can be fairly closely estimated It has already been shown (Table 3) that milk and milk products may be valued at about 300 crores of rupees This is roughly equivalent to the value of India's total output of rice and is three to four times the value of the output of wheat(²) Miscellaneous products such as hides, skins and offals are also an important though relatively small source of income from cattle especially as these are largely sold for export India is in fact, the largest exporter of hides and skins in the British Empire her products representing one third of the total Empire exports(³) India's yearly output of this group of products is valued at roughly 40 crores of rupees It is significant that the trade in hides and

(¹) U S Dept Agric Yearbook 1935, pp 556 557 The figures quoted refer to the years 1926 1930 According to the Fourth Census of Live Stock held in 1935 the total cattle population of India is now estimated at 215 millions

(²) The production of rice is estimated at 33 million tons At Rs 100 per ton this gives a value of 330 crores of rupees The production of wheat is estimated at 9½ million tons At Rs 80 per ton this gives a value of 76 crores of rupees

(³) A N Duckham "Animal Industry in the British Empire," p 222 Oxford University Press, 1932 In 1928 the total Empire exports of hides and skins were valued at £42,200,000, of which India's share was £14,000,000

skins, which represents only a minor by-product of the cattle industry, has a greater monetary value than the total Indian output of sugar, which is valued at about 30 crores of rupees(4). It may also be mentioned that, although the export of live cattle does not represent a large source of income, the potentialities of Indian draught breeds have in the past been widely recognised, the annual export at one time having reached nearly 2,000 animals at an average value of Rs. 250 per head.

It is, however, in the relation of cattle to the agricultural economy of the country that their unique value becomes apparent.

Value of cattle labour.

Cattle labour represents probably the most important contribution of live stock to Indian agriculture. In the words of the Royal Commission on Agriculture in India(5) "In most parts of the world cattle are valued for food and for milk; in India their primary purpose is draught for the plough or the cart...... Without the ox, no cultivation would be possible; without the ox, no produce could be transported". It is obviously difficult to place a definite monetary value on cattle labour. An inquiry into the value of cattle labour in holdings in the Punjab(6) has shown that between 15 and 20 per cent. of the costs of cultivation fall under this head, a figure which has I understand been confirmed in a more recent investigation(7). Assuming that the total value of India's output of agricultural produce approximates 2,000 crores of rupees(8), the share of cattle labour would be between 300 and 400 crores of rupees. An alternative method of calculation may be taken from the Royal Commission's Report(9) where it is estimated that the cost of feeding and depreciation of a pair of bullocks averages Rs. 175 per year. On the Commission's assumption that a pair of bullocks are needed to cultivate 10 acres of 'net sown area' (of which there are 230 million acres in British India and 70 million acres in Indian States) the cost of cattle labour works out at 525 crores of rupees for all India or 400 crores of rupees for British India. The latter value may therefore be taken as a conservative estimate for the country as a whole.

The second indirect source of income attributable to cattle which is, however, even more difficult to assess is their contribution to the fertility of the land. An attempt has been made to arrive at a rough estimate of the cash value of cattle manure, and a provi-

(4) *i.e.*, an output of 1,200,000 tons of sugar at Rs. 150 per ton and an output of *gur* of 4,000,000 tons at Rs. 50 per ton.

(5) Report of the Royal Commission on Agriculture in India, p. 169. Cmd. 3132 (1928).

(6)

(7) Investigation carried out under the direction of the Imperial Council of Agricultural Research.

(8) The figure given by Findlay Shirras ("The Science of Public Finance") for 1922 was 1,983 crores of rupees. According to M. Vaidyanathan (private communication) this had risen in 1929 to 3,400 crores, but had fallen again by 1936 to 2,000 crores.

(9) *Loc. cit.*, p. 194.

sional figure of 270 crores of rupees has been suggested(10). This figure is obviously open to criticism, as indeed would be any estimate based on the very meagre information available. No figures exist, for example, to show what proportion of cattle dung is used as fuel, although this is believed to be very large. Nor have controlled experiments been carried out to determine the value of farm-yard manure under the widely varying climatic and soil conditions of India. There is little doubt that the widespread extension of 'composting' would greatly enhance the value of cattle manure as a medium for increasing soil fertility.

Cattle as a factor in maintaining soil fertility.

I believe that it is necessary, however, to look at this subject from the wider aspect of the possible effect of a 'mixed farming' system on the productive capacity of the land. At present India is virtually attempting to maintain a relatively dense human population by methods only applicable to an 'extensive' system of farming, a system in which large acreages have to be relied upon to off-set low crop yields and poor grazing lands, and in which little attention is paid to the maintenance of soil fertility. Such methods may be suitable for newly developing countries, such as Australia and Canada, where the human population is small and ample land is available. In these two countries there is, however, an average of only two to three persons per square mile. In India there are nearly 200 persons per square mile, a figure nearly equivalent to that of Denmark. With such dense populations it is essential that the output of produce per acre should be high, and for this purpose the fertility of the soil must be maintained. It has aptly been said that under these circumstances the development of Indian agriculture urgently requires "the dove-tailing of the arable and animal husbandries into one 'mixed-farming' system". "It is evident" states the same authority(11) "that the cattle problem dominates the whole situation...... I think that no rapid increase (in crop yields) can come until the 'mixed-farming' system is adopted." Such a 'mixed-farming' system would involve not only the utilisation of all available manure, but the cultivation of leguminous fodder crops which contribute so markedly to soil fertility. The fodder crops so grown would, in turn, provide an ideal source of food for cattle, and particularly for milking stock.

This is, therefore, a question of the utmost importance not only to the cattle industry but to the whole future development of dairying. At present one is faced by a somewhat perplexing problem. Milk is chiefly produced as a by-product of agriculture: the milking stock are largely fed on dry fodder which would otherwise be valueless, and the labour costs are negligible. Under such conditions the cultivator can afford to sell his milk at a remarkably low price, 6 pies per lb. being not uncommonly accepted.

Would mixed farming cheapen milk production?

(10) A. Olver and M. Vaidyanathan. "Assessment of the Annual Contribution of Live Stock in India to Indian Economy."

(11) B. A. Keen. "The Real Problem in India." Paper read before the Royal Institute of International Affairs, March 1st, 1932.

On the other hand figures obtained from a study of the costs of production of milk on Military Dairy Farms(12), as well as from other large dairy concerns, give costs of production of from 6½ to 11 pies per lb., while another independent investigation showed a figure of just over 1 anna per lb.(13). The specialised production of milk does not appear, therefore, to be economically feasible unless an exceptionally good market is available. It has been suggested that the way to increase milk production in India is to create a more lucrative outlet for milk and milk products. This might be true in a country with a large and relatively rich urban population : it is not, I believe, applicable to Indian conditions where 90 per cent. of the population are rural, and where a large proportion of the cultivators are compelled to live on a subsistence agriculture. Moreover, the provision of a more lucrative outlet for the milk is not consistent with the prime necessity (referred to in Chapter I) of maintaining a low price for milk in order to stimulate increased consumption.

The solution of the problem appears to me to be along the lines indicated above, namely, the development of a 'mixed-farming' system. In such a system the production of animal products such as milk is carried on side by side with a system of cropping in which leguminous fodder crops take an important place, and in which full use is also made of the increased quantities of cattle manure. In this way soil fertility is maintained, and the resulting increase in crop yields indirectly off-sets any increase in the cost of production of milk. It is significant to note the success of such a 'mixed-farming' system in another backward agricultural country(14). "Larger yields of crops are being secured and the farmers, in addition to having more ample food supplies and larger quantities of economic crops for sale, are also being provided with supplies of animal products, such as milk and butter, for their consumption and sale. There is no doubt that they have been enabled to live better than was possible under the old order, and in consequence it is expected that their own health and that of their families will benefit."

It is of course questionable how far 'mixed-farming' can be introduced under the wide variety of climatic and soil conditions of India. There is, however, little doubt that there is great scope for development along these lines in many irrigated tracts. At present there is a very general impression that the introduction of irrigation rapidly leads to the deterioration and even to the virtual extermination of good breeds of cattle. This is, for example, true of Sind and of certain tracts in the United Provinces. If full advantage is

(12) K. P. R. Kartha. "A Note on the Comparative Economic Efficiency of the Indian Cow, the Half-bred Cow, and the Buffalo as producers of Milk and Butter-fat." Animal Husbandry Wing Meeting, February 1933.

(13) W. J. Hansen and N. R. Joshi. "Cost of Milk Production in Allahabad." *Agric. and Live Stock in India,* 4, 248 (1934).

(14) F. A. Stockdale. "Report on the Agriculture of Nigeria, the Gold Coast and Sierra Leone." Colonial Advisory Council Publication No. 270 (1936).

to be derived from irrigation, I am convinced that farming in irrigated areas will have to be modified to allow the inclusion of a 'mixed farming' system in which both the crop and animal husbandries play their part.

Conclusions.

This brief discussion is, I think, sufficient to give some indication of the magnitude of the cattle industry and of its actual and potential value to Indian agriculture. In actual value (including the value of dairy products) the industry contributes at a very rough estimate about 1,000 crores of rupees to the agricultural income of the country, which has been assessed at a total of 2,000 crores of rupees. The potential value of cattle as a means of raising the level of fertility of the soil and of thus increasing the output of both cash and food crops is, I believe, incalculable.

CHAPTER VIII.—General Discussion on Cattle Improvement.

Before dealing in detail with the problems involved in the breeding and feeding of dairy cows, it seems desirable to discuss briefly the steps which have so far been taken to improve the general standard of Indian cattle. I should make it clear that the measures adopted have been largely limited to draught breeds and general utility animals, and have not included milking breeds. A very full discussion of the measures necessary to improve Indian cattle is given in the Report of the Royal Commission on Agriculture. It is not necessary for me to recapitulate the conclusions of the Report. It may, however, be said that the two chief methods of improvement adopted have been the provision of pedigree and improved bulls, and the castration of inferior males. It will be instructive to see how far effect has been given to the Royal Commission's recommendations in these two matters.

Issue of pedigree bulls.

As regards distribution of pedigree bulls issued from Government Farms, the Royal Commission drew attention to the very limited progress achieved up to 1926 in comparison with the needs of the cattle population of the country(1). The Commission calculated that an annual supply of some 200,000 bulls was needed, but showed that in the major provinces only a little over 500 per year were actually issued. Table 23 indicates the comparatively slow progress made since the date of the Commission's Report. Although the number of bulls issued annually from Government Farms has been nearly doubled, the total is still only a minute fraction of India's requirements. These figures do not, however, show the total number of bulls issued, since approved animals from sources other than Government Farms are also distributed in certain provinces. Thus 300 to 400 approved bulls are distributed annually in the United Provinces, 40 to 50 in Bombay Presidency, and 20 to 30 in Bengal. A fairer estimate of progress is therefore given by the number of pedigree and approved bulls actually at stud. These are shown in Table 24. The Royal Commission estimated that India needed roughly one million breeding bulls ; the present number of pedigree and approved animals represents only one per cent. of this requirement. Moreover it is significant that the number of new bulls issued each year is only slightly greater than that needed to replace existing animals on a 10 to 15 per cent. basis of annual wastage.

It may be urged with some justification that these figures give a misleading impression of the real success achieved by the policy of bull distribution, since they give no measure of the actual improvement in local stock which has taken place as a result of the scheme. There is no doubt that such improvement has been most marked : it was indeed apparent to me during my tour that in those areas in which pedigree or approved bulls had been placed the stock were invariably of an improved physique and appeared to be better cared for. It is, however, unfortunate that some quantitative measure of

(1) Report of the Royal Commission on Agriculture in India, p. 213. Cmd. 3132 (1928).

improvement is not available It is here, I believe, that breeding control and the registration of progeny would be of special value Such a system of registration would not only provide a measure o the progress achieved, but would also provide a reservoir of improved stock for distribution to other districts Probably the best example of the application of this system is to be found in the Bombay Presidency* Here, although there are only 289 bulls noted as 'at stud', there is a register of over 2 000 improved cattle Similar systems have also been adopted in the North West Frontier Province and in certain tracts in the Punjab

Pedigree versus approved bulls

This raises the general question as to whether in attempting to accelerate progress in live stock improvement reliance can be placed on bulls selected from improved cattle tracts as well as on bulls bred at Government Farms On the one hand it has been urged that the breeding records of stock reared under village conditions have a high degree of unreliability, and that such animals could not adequately replace the farm bred bulls of guaranteed pedigree On the other hand it has already been pointed out that the number of farm bred bulls is seriously limited and quite inadequate for the needs of the country Farm bred bulls are, moreover stated to be unsettled and difficult to handle, while they do not always represent the type of animal which the cultivator requires There is too, the question of cost Farm bred bulls are relatively expensive to rear I was for instance, informed that bulls at two large provincial centres cost from Rs 200 to Rs 400 to rear, while they were sold to District Boards for distribution in villages at Rs 100 Village bred bulls, on the other hand can be reared at almost negligible cost to Government Moreover the purchase of village bred bulls for distribution gives a most valuable stimulus to improved cattle breeding in the selected areas by providing a market for such improved stock Government is giving direct encouragement to progressive breeders

I think that this question might be summed up by saying that if any widespread effect is to be obtained by the distribution of bulls, it is essential that increasing use should be made of the improved (and registered) animals bred under village conditions in selected breeding tracts Only by this means will it be possible to supply the vast number of breeding bulls required throughout India On the other hand it is equally necessary that 'type' should be preserved within each breed For this purpose it is I believe essential to maintain Government breeding farms where the methods of breeding can be accurately controlled and breeding records can be thoroughly relied upon

The problem of the scrub bull

The second general method of effecting cattle improvement on an extensive scale is by the castration of all inferior males The number of animals castrated at veterinary hospitals and dispensaries and on tour have more than doubled during the last decade as

*E J Bruen "A Note on the Establishment and maintenance of Pedigree Herd Books in Bombay Presidency" Animal Husbandry Research Workers' Conference, New Delhi, February 1936

shown in Table 25. Progress in this direction has, however, varied from province to province, and it is significant that two-thirds of the total number of castrations have been done in three provinces, the remaining provinces showing very small returns (Table 26). It is, of course, extremely difficult to determine the extent of improvement of stock which has taken place as a result of this widespread castration policy. No records are available to show what proportion of castrations are carried out on the undesirable types of ' scrub ' bull, and what proportion merely replace castrations previously carried out by the more crude village methods(2). It is stated that there is difficulty in getting young stock castrated at a sufficiently early age, a point which formed the subject of one of the recommendations of the Royal Commission. This recommendation, which was that experiments should be carried out to determine the effect of early castration on subsequent development(3), does not appear to have been put into effect.

While it is difficult to assess the value of the present castration policy so far as the country as a whole is concerned, there is, I feel, one direction in which future action should be concentrated, namely, the intensification of castration measures in selected breeding areas. A policy which included the distribution of pedigree bulls to selected areas and the registration of progeny in those areas, combined with the castration of all inferior male stock and if possible the inoculation of all local stock against rinderpest, would represent an ideal method of effecting live stock improvement. If, as I recommend in a later chapter, breeding, castration and disease control are placed under a single Department, it should not be difficult to ensure that a real drive is made along these lines in the direction of improving India's cattle.

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(2) It is interesting in this connection to note the comment of one Director of Veterinary Services " In areas where the local zamindars are deriving benefit from cattle breeding they very definitely discriminate against the scrub bull, and we have comparatively little difficulty in castrating their inferior male stock ".

(3) *Loc. cit.*, p. 238.

CHAPTER IX —The Breeding and Management of Milch Cattle

In the previous chapter I have dealt with certain general methods of effecting improvement in the breeding of Indian cattle under village conditions These methods have so far been chiefly applied to cattle of draught type In the present chapter I propose to discuss in detail the breeding and management of cattle of pre dominantly milking type

Importance of increasing per capita milk yields

I have already stressed the need for increasing and cheapening *milk production in India it the population is to be able to secure* adequate supplies of milk at a reasonably low price There is probably no single measure which could do more towards achieving this aim than an improvement in the milk yields of Indian cattle At present the milk yields of village cattle are exceptionally low Table 33 shows, for example, typical yields as estimated in recent surveys(1) for British India The average is only a little over 600 lb per year, which would represent an average daily yield of, say, 4 to 6 lb On theoretical grounds alone this yield is bound to be uneconomic, since the amount of food required for the maintenance of the cow is very high in comparison with its production requirements Any increase in the *per capita* yield would spread this maintenance cost over a larger output of milk, with a consequent lowering of food cost(2) The cost of labour and of depreciation of stock would also be reduced with the higher yield Table 27 shows that this conclusion is borne out in prac tice(3) The figures show clearly that the higher the yield the lower are the relative costs of labour, depreciation and food Moreover it is significant that the reductions in the relative costs of these items are greatest at the low levels of milk production which are character istic of Indian village cattle Figure 1 illustrates this fact in rela tion to feed costs(3) It will be seen for instance, that by raising the level of milk production from 7 lb to 14 lb per day the food require ment per lb is reduced by nearly 50 per cent Figure 2(4) shows that this finding is identical with that arrived at independently in

(1) Results of Provincial Marketing Surveys

(2) This statement needs amplification It has been stated in Chapter VII that the cultivator can afford to dispose of his milk at a price below the costs of production as found on Military Dairy Farms and other specialised milking herds The cultivator's present method of milk production is however only cheap in the sense that it does not involve him in any direct additional ex penditure the animals being fed on the by products of the cultivation of food crops such as rice, wheat maize and millet But it is in fact an extremely uneconomic method of milk production The low yields involve a relatively high cost of maintenance per unit of milk produced poor feeding delays the attain ment of maturity and therefore lengthens the unproductive period of life while inadequate nutrition and poor management also tend to lengthen calving periods and therefore to reduce the total output of milk during the life span

(3) K P R Kartha "A note on the comparative economic efficiency of the Indian cow the half bred cow and the buffalo as producers of milk and butter fat" Animal Husbandry Wing Meeting February 1933 The figures refer to animals of different breeds, but serve to illustrate the general principle involved

(4) U S Yearbook of Agriculture (1935), p 599

other countries. The trading results of a well-known herd of Indian dairy cattle may be quoted as an example of the benefit derived from high milk yields(5). While the average milk yield of the cows in this herd was below 4,500 lb. there was a constant trading loss averaging about Rs. 1,500 per year. An increase in the *per capita* milk yield to between 5,500 and 6,300 converted this loss to an average profit of Rs. 1,200 per year. While other factors may to some extent have contributed to this achievement, the correlation with increased milk yield is too clear to be a mere coincidence.

These facts will serve to emphasise the importance of improving the milk yields of Indian cattle. It is, however, equally necessary to take into account the diverse needs of the different branches of the Indian dairy industry in deciding the breeding policy to be adopted. It will be understood that these needs vary according to local circumstances. For city milk supplies, for example, an animal is required which will give relatively high yields. Fodder is costly, and the rent of premises is also a heavy item of expenditure. Only a high producing cow can be maintained economically under such conditions. At the other extreme there are draught breeds in which the primary purpose of retaining the cow is to produce good working bullocks. Milk is here an entirely secondary consideration, though it is obviously desirable to obtain as much milk as possible from the cow provided that this does not result in any deterioration in the inheritance of draught quality. Between these two extremes there are so-called 'general utility' stock which give bullocks of reasonably good physique, and cows with a fair though not high milk yield. The breeding policy to be adopted will obviously depend on the nature of the local requirements as well as on the type of cattle available.

Need for considering local requirements.

It is, however, also essential that, having decided what policy to adopt, this should be continued uninterrupted over a long period of years. There is no branch of animal husbandry in which changes of policy can do so much harm as in breeding : if the changes are frequent no constructive breeding is possible ; on the other hand if a policy which has been maintained over a long period is ultimately abandoned through some adventitious factor such as temporary financial stringency, many years of constructive work will be wasted. Unfortunately I found that the value of adopting long-range cattle breeding policies had not in the past been sufficiently appreciated in India. There was a general tendency to change the method of breeding prematurely if satisfactory results were not quickly attained. As an extreme example I may quote one College dairy herd, in which seven changes had been made in the breeding methods over a period of less than 25 years. The adverse results of this vacillating policy were quite apparent at the time of inspecting the herd. There are also instances in which the results of valuable breeding work has been destroyed by precipitate Government action. The history of the Scindi breed provides one of the worst instances of such short-sighted policy.

Long range policies.

(5) Private communication from Lyallpur Agricultural College.

I have felt it desirable to stress these two points—the necessity of formulating breeding programmes to meet local needs and the urgency of ensuring that such programmes are not prematurely interrupted—because they form the foundations of any successful breeding policy I will now turn to certain questions which are of special importance in deciding on breeding policies in India

Owing to the relatively low milk yields of indigenous Indian breeds it is, perhaps, natural that breeders have tended to rely on cross breeding with sires of high yielding European breeds to raise the productivity of local stock This policy has been widely adopted by the Military Dairy Farms and also certain Agricultural College dairy herds The immediate results are certainly striking The first cross (half bred) gives on an average double the yield of its indigenous dam, while it also breeds more regularly With further crossing the results have not however, been so successful Mating half bred to half bred is of very questionable value , even if a fixed type could ultimately be obtained (which is doubtful) the amount of ' culling ' of unsatisfactory animals would make the method extremely expensive Back crossing improves the constitution but reduces the milk yield Forward crossing on the other hand while maintaining milk yield is liable to result in a deterioration of physique and in high mortality, particularly among calves This latter difficulty has to a great extent been overcome by improved technique in calf rearing Deterioration in the constitution of adult stock appears to be due not so much to the cross breeding as to the effect of high milk yield under the rigorous climatic conditions of India Thus it has been shown that there are indications of increased susceptibility to disease and loss of constitution even among Indian dairy cattle when their milking performances improve[6] Typical milk yields of the various crosses are shown in Table 28 The striking and immediate effect of the introduction of European blood on milk yield is clearly shown

Indigenous versus cross breeding

It must, however be emphasised that these results have been obtained in herds in which there have been exceptional facilities for the control of breeding At other centres where cross breeding has been practised the results have not been so satisfactory Even in some College herds the deleterious effect of badly controlled cross breeding is apparent from a superficial inspection of the stock Moreover at Military Dairy Farms and in Agricultural College herds the animals receive adequate and well balanced rations In this connexion I would emphasise a point which has been made in a recent publication namely, that while European cattle have been bred to carry those characters which assist the effective use of the largest possible quantity of food Indian cattle have been developed to make the most efficient use of the smallest quantity of food[7] It is not surprising therefore that in the hands of *gowalas* and similar uneducated owners of milking stock the results of cross breeding have

(6) K P R Kartha (loc cit)

(7) J Matson " Cattle in relation to Agriculture in India " *Journ Cent Bur Animal Husbandry and Dairying in India*, 2 83 (1928)

frequently been disastrous. Type is entirely absent, the animals may or may not give good yields of milk, and there is a noticeable deterioration in physique. Such results are inseparable from uncontrolled methods of cross-breeding combined with indiscriminate feeding. It is for this reason that I am convinced that, however valuable cross-breeding may be in herds which are under expert control, the general adoption of a policy of cross-breeding to improve the yields of country stock would be fatal to the development of sound dairying in India.

Value of indigenous milking breeds.

If, however, cross-breeding is to be discouraged, what alternative remains which will provide animals of equally satisfactory milking capacity? The answer to this question may be found in the extensive breeding experiments which have been carried out at various centres and which show that by careful selection indigenous strains of Indian cattle can be built up which are capable of giving remarkably high milk yields. Table 29 shows the improvement effected in four prominent Sahiwal herds. This improvement has been extremely rapid, the average milk yield in two of the herds having been more than trebled within 20 years. Table 30 shows the distribution of milk yields of three other pure-bred Sahiwal herds. In comparison it may be noted that the average lactation yield of the Ferozepore herd over the past four years has been roughly 7,000 lb. milk in an average of 340 days. Out of 290 recorded lactations 30 exceeded 8,000 lb., 16 exceeded 9,000 lb., and 6 exceeded 10,000 lb. These figures not only show the marked and rapid improvement which can be effected through careful breeding, but indicate that the levels of milk yield finally obtained are comparable with those found for average European stock(8). Other breeds have not received so much attention as the Sahiwal, but there is evidence to show that these also have great potentialities for milk. The average yields of animals in the Hariana and Tharparker herds which were established by the Imperial Dairy Expert at Karnal in 1923 have increased from under 9 lb. to between 13 and 14 lbs. The average lactation yields of animals in these herds are now over 3,500 lbs. in 300 days. Scindi cattle have not been so carefully studied, but there are indications that this breed also has high milk potentialities. At the Hosur Cattle Farm the average lactation yield of the Scindi cows is 3,250 lbs. milk in just over 300 days. At the Imperial Dairy Institute they have shown a 20 per cent. increase in yield in three years.

I do not think that it is necessary to quote further examples of the potentialities of indigenous Indian breeds to give high milk yields. The policy of encouraging the breeding of such indigenous stock in preference to cross-breeding has been strongly advocated in other tropical countries. In a Report on Cattle Breeding in Jamaica and Trinidad(9), Dr. Hammond states "Apart from the time it

(8) According to Agricultural Statistics (1935) the average lactation yields of British dairy cattle were 4,820 lb. and 5,390 lb. in 1924-25 and 1930-31 respectively.

(9) John Hammond. "Report on Cattle-Breeding in Jamaica and Trinidad". Empire Marketing Board Publication No. 58 (1932).

would take, I can find no evidence that mere selection (combined with better feeding) of the local stock would not produce equally good results There can be little doubt that European stocks, *even when bred pure,* gradually lose their type under these (tropical) conditions and require continual importations to maintain their form and constitution " Mr F A Stockdale, writing of conditions in Nigeria(10) states " The introduction of strains from outside will only add to the complications which already exist and produce an even more heterogeneous collection of animals than at present exist In my view a policy of rigid selection from the local cattle would be more calculated to produce results of lasting value than could be achieved by the introduction of the blood of strains of cattle from outside " I consider that these views are equally applicable to Indian conditions

In practice, however, one of the difficulties is that the building up of high milk yielding strains is relatively slow in comparison with the immediate results obtained by cross breeding with European stock On account of this fact it appears almost inevitable that reliance will continue to be placed on cross breeding for high milk yield until there is a sufficient nucleus of high yielding Indian cattle to supply the necessary number of improved stock for use in localities where high milk yields are specially desired, as for example in the production of milk in the vicinity of cities and large towns This indicates the extreme urgency of taking immediate steps to extend the facilities for selecting and improving indigenous milking strains of Indian cattle Definite proposals with this object in view are put forward in Chapter XII

Desirability of developing higher milking strains

I should perhaps add that I do not consider that such efforts should be limited to those breeds which are recognised as predominantly milking types Table 31 shows that improvement can be looked for in the milking capacity of most breeds other than those of purely draught type, such as the Amrit Mahal and the Hissar breeds Even the latter breed is found to possess strains of special milking potentialities In any such breeding for milk yield among draught cattle it is, however, essential to guard against deterioration of draught qualities This point was stressed by the Royal Commission on Agriculture who stated that " in attempting to secure more milk from the five types of draught cattle still to be found in many parts of India there is a real danger that the qualities which have in the past commended them to cultivators will be lost "(11)

(10) F A Stockdale " Visit to Nigeria Gold Coast and Sierra Leone " Colonial Advisory Council Publication No 270 (1936)

(11) I have not felt it necessary to discuss the controversial questions involved in dual purpose breeding I believe that the controversy is largely founded on a misconception of the genetic implications of such breeding as well as of the needs of the cultivator The subject has been adequately dealt with by Sir A Olver in an article entitled " The Inadequacy of the Dual Purpose Animal as a Goal of Cattle Breeding in India " *Agric and Live Stock in India* 6 389 (1936) It is also referred to in an informative paper by Colonel A Matson entitled " Cattle in relation to Agriculture in India " *Journ Cent Bur Animal Husb and Dairying in India* 2, 185 (1928)

An essential step in developing high milking strains of Indian breeds of cattle is the establishment of herd-books and of a system of milk records. In purchasing draught cattle it is possible to judge the merits of an animal by its conformation and performance. Milch cattle, however, present a different problem since conformation is only one indication of milking capacity, and performance can only be judged from carefully kept records.

The need for registration of milch cattle.

Preliminary steps have already been taken in this direction. Through the initiative of the Imperial Council of Agricultural Research, information has been collected which will enable the characteristics of the seven chief milking breeds to be defined(12). This is obviously the first essential step in the establishment of herd-books. Arrangements are being made to open the herd-books and to establish milk records systems at an early date. I shall refer to this proposal in more detail in Chapter XII. At this stage I should, however, point out certain incidental advantages of the scheme. In the first place it will provide a most useful index of progress in the breeding of milking types. At present there is no systematic information available on this subject. It is known that the yields of individual herds show improvement and that the number of animals of proved milking strains is increasing. There is, however, no central authority which is in a position to collect this scattered information and collate it into a form which will show the extent of progress achieved. In the second place the collection of milk records will form a most valuable source of information for future investigations into factors affecting the yield and quality of milk. This has been the experience in Great Britain, the United States and other advanced dairying countries, and it should prove of even greater value in India where conditions are so diverse and where accurate records are difficult to obtain. I should point out that investigations into such subjects as the shape of the lactation curve and the effect of age on lactation yield are of more than academic importance. The results of such investigations enable milk yields obtained under different conditions to be standardised to a single basis of comparison, a procedure which is essential for a true judgment of milking performance(13). In the third place the defining of types in connexion with the establishment of herd-books will be of direct educational value to practising agriculturists as well as to students of agriculture and veterinary science. I was, indeed, somewhat surprised to find that at many educational centres the only diagrams for use in explaining the 'points' of milch cattle were those issued in connexion with European stock-judging. It is obviously desirable that Indian students should be taught stock-judging in relation to their

(12) The breeds so far included are the Sahiwal, Scindi, Tharparker, Hariana, Gir and Ongole, and the Murrah buffalo.

(13) Work of this nature has already been carried out by L. C. Sikka. *Indian Journ. Vet. Science and Animal Husbandry* 1, 63 (1931) and 3, 241 (1933), and by K. P. R. Kartha. *Ibid.* 4, 36, 124 and 218 (1934). The establishment of a proper system of milk records will enable the results of these authors to be confirmed and extended.

own dairying types, and not to imported breeds I might note also that a scale of points for judging buffaloes did not appear to be used at the majority of colleges This also should be remedied when the definitions of herd book types are once available

These three advantages are, of course, entirely subsidiary to the main purpose for which the herd books and milk record registers are to be established They serve to show, however, that apart from its purely commercial aspect, the proposal is of direct value from the point of view of both education and research

The cow versus the buffalo

The Royal Commission rightly stressed the importance of she-buffaloes as the chief milk-producing stock in India Thus they wrote that " it is the number of she buffaloes, not the number of cows that has to be taken into account when seeking an index of the milk production of a province Wherever an important market for *ghee* exists, it is the she buffalo which mainly supplies it "[14] It is indeed not difficult to explain the popularity of the she buffalo Her average milk yield is markedly higher than that of the ordinary village cow, the butter fat content of her milk is also higher than that of cows' milk, while she appears to possess a remarkable ability to convert coarse fodders into milk In view of the poor nature of the fodder normally available under village conditions and the hard conditions under which the animals have to live, the hardiness of the she buffalo is a most valuable asset to the cultivator

The growing popularity of the buffalo is reflected in the census statistics Table 32 shows the number of cows and she buffaloes recorded at five year intervals during the past twenty years[15] It will be seen that while the number of cows has scarcely altered the number of buffaloes has risen by 13 per cent The importance of the buffalo is also seen in Table 33 which shows the number of cows and she buffaloes their relative milk yields, and the extent to which they contribute to the total milk production[16] Numerically cows exceed she buffaloes in every province but the Punjab The she buffalo makes up for this deficiency, however, by her higher milk yield with the consequence that in five out of the ten provinces she actually produces more than half the total milk production It is significant that the main *ghee* producing areas of India are situated in these provinces In British India she buffaloes provide 47 5 per cent of the total milk supply , in India as a whole (though the figures are incomplete) they provide nearly 45 per cent [17]

The value placed on his she buffaloes by the cultivator is also apparent from their better nourished appearance in comparison with country cows, and from the fact that even under village conditions their milk yields are exceptionally high It is questionable whether under present conditions of feeding and management the milch cow

(14) *Loc cit*, p 184

(15) Agricultural Statistics of India, 1934 35

(16) Results of Provincial Marketing Surveys

(17) These figures exclude the output of goats' milk

could displace the buffalo : as has been aptly stated "when prices of fodder are low the she-buffalo can compete with any breed in butter production and beat the ordinary Indian cow in the production of both milk and butter. This is the main reason why the villager prefers the buffalo to the cow notwithstanding the fact that he has to pay a higher price for the buffalo "([3]). Whether the same argument would hold if the cultivation of better types of fodder crops were to be widely employed is doubtful. The Military Dairy Farms have found that under good conditions of feeding and management the ordinary Sahiwal can produce as much milk as the buffalo, while high milking strains of the breed will produce over half as much again. On the other hand it should be pointed out that no serious attempts appear to have been made to improve the milk yields of buffaloes by selection and breeding from high yielding strains—a subject which is worthy of extensive study. In the meantime it is certain that for many years the she-buffalo will more than hold her own in competition with the cow as the premier milk producing animal of India.

The management of milch cattle.

In a country which has an exacting climate such as that experienced in the plains conditions of India, management is an extremely important factor. This is true even under village conditions, where high milk yields are not looked for. But with intensive milk production there is bound to be a constant rivalry between constitution and economic performance. This is a subject which has received comparatively little attention in India. It is therefore extraordinarily interesting to find that where systematic investigations have been carried out (as in the Military Dairy Farms) it has been shown that the preservation of constitution is a very definite limiting factor in attempts to improve milk yields beyond a certain level. It has been found that this maximum limit of milk production is affected by numerous external factors, such as diurnal and seasonal variations in temperature, the humidity and the extent of artificial protection given to the animal against excessive heat. Cross-bred stock are more susceptible to such influences than pure-bred Indian stock, and these in turn are more susceptible than buffaloes. These conclusions have not only been reached by general observation, but by direct physiological tests such as a study of the respiration rate and body temperature.

Any breeding policy must, in fact, take very carefully into account the environmental conditions under which the animals have to live. Attempts have, for example, been made to improve the size and draught quality of dwarfed country-bred stock by supplying sires of a larger physique. Such attempts may do more harm than good unless they are accompanied by measures to improve the environment of the stock, including their feeding. It is interesting to note in this connexion that the special distribution of a thousand improved bulls which forms part of the recent cattle improvement scheme in Bengal has been accompanied by the distribution of over a million cuttings of Napier grass.

The constitution of milking stock is closely related to other factors concerned in management. Early maturity and increased frequency of calving are two such factors. In a series of interesting experiments at the Imperial Agricultural Research Institute[18] it has been shown that heifers of Indian milking herds can be calved successfully at far earlier ages than had hitherto been deemed possible, while at this and at other centres the length of the ' dry ' period has also been markedly reduced. These changes in technique are obviously valuable from an economic point of view, since they tend to shorten the periods of unproductive life. The investigations have, however, so far been carried out only under optimum conditions of feeding and management. It remains to be seen whether they could be applied under the adverse environmental conditions commonly existing in less efficiently run herds. It is indeed quite possible that the late maturity and long dry periods of country-bred stock constitute natural safeguards against overstraining the constitution of inadequately nourished stock, giving opportunity for growth and for the replacement of body tissues utilised in the production of milk.

These and other points of management are of fundamental importance for the maintenance of a sound constitution in high milking stock. In the past insufficient attention appears to have been paid to this subject I am strongly of opinion that the matter should be looked on as one of the major subjects for investigation in connexion with the breeding of improved stock.

The physiology of reproduction.

This discussion would not be complete without a brief reference to the potential importance for the Indian cattle industry of recent investigations into two subjects, namely, hormone therapy and the technique of artificial insemination. Hormone therapy provides a possible method of treating the various breeding irregularities which are found among Indian stock Some success has already been achieved in this direction but the subject is one which merits much close and continuous study in conjunction with a well equipped laboratory. The technique of artificial insemination has now reached a stage when it is capable of widespread application in the breeding of live stock. It has been practised with great success in the Soviet Union, where it was necessary to build up large herds of improved stock within a relatively short period of time[19] India is, of course, faced with an exactly similar problem. It is very questionable how far the method could be applied as a direct means of improving country stock : the difficulties of transport, the lack of communication, and the ignorance and probable prejudice of the cultivator would present almost insuperable obstacles. There is, however, no doubt that the utility of the method ought to be investigated in some of the large Government cattle breeding centres, where adequate facilities are available and where breeding control is possible.

(18) Wynne Sayer. "Feeding and Handling Experiments on the Pusa Pedigree Sahiwal Herd." *Agric and Live-Stock in India*, 4, 105 and 181 (1934). Also personal communications.

(19) A. Walton. "The Technique of Artificial Insemination." Imperial Bureau of Animal Genetics, Edinburgh (1933).

CHAPTER X.—The nutrition of milch cattle.

India's total fodder resources.

There is no doubt that the majority of Indian dairy cattle are seriously underfed. This is apparent from a superficial inspection of village stock, which lack the sleekness and bloom of well fed cattle and not unfrequently have an emaciated and malnourished appearance. It is equally apparent from the slow rate of growth, the late maturity and the long dry periods of Indian cattle which are kept under village conditions. Thus it is quite usual for a cow to drop her first calf at 4 to 5 years of age, and to have calving intervals of up to 600 days. That these are not hereditary failings is proved by early maturity and controlled breeding experiments in herds where the feeding and management are satisfactory. Moreover, it is significant that a careful analysis of the yields of purchased cows show that such animals give an average increase of 60 per cent. in their milk yields solely as a result of better feeding and management. It may indeed be stated that inadequate nutrition is at present the most important single factor in accounting for the low yields of 'country' cows. "We are satisfied" the Royal Commission have stated(1) "that no substantial improvement in the way of breeding is possible until the cattle can be better fed."

It is difficult to arrive at any accurate estimate of total quantities of feeding stuffs available in India. This is partly due to the inaccuracy and inadequacy of available statistical data. It is also partly due to the fact that little attention is paid to the feeding value of the different types of fodder. It is very desirable that steps should be taken to improve the sources of information at present available on these two subjects.

I have, however, attempted to arrive at a figure, admittedly approximate and open to criticism, which would give some indication of the quantities of feeding stuffs available for cattle. This information is summarised in Table 34. Dry fodders refer to the estimated quantities of straw derived from rice, wheat, barley, *bajra*, and *juar*(2). Green fodders have been calculated on the basis of an average yield of 200 maunds per acre and a total crop area (for all India) of 14,000,000 acres. The figures for concentrates and cottonseed are rough estimates(3). The nutrients have been calculated from standard American tables(4). It is probable that the quantity

(1) Royal Commission on Agriculture in India. Cmd. 3132 (1928), p. 201.

(2) Figures obtained from Agricultural Statistics of India, 1934-35. The following grain|straw ratios have been used :—for rice 1 : 1½, for wheat and barley 1 : 2, for *bajra* 1 : 2½, and for *juar* 1 : 3. In addition allowance has been made for straw obtained from pulses and certain unspecified grain crops. These occupy an area of about 66 million acres, and, allowing the low figure of ¼ ton per acre, will provide about 16 million tons of coarse fodder.

(3) The estimates of individual oil-cakes in thousands of tons are linseed 99, groundnut 622, mustard and rape 516, cocoanut 60, miscellaneous (say) 200. Cottonseed, calculated on a production of 6½ million bales of cotton, will total 2,300,000 tons.

(4) W. A. Henry and F. B. Morrison. "Feeds and Feeding." The Henry Morrison Company, Wisconsin.

of dry fodder is seriously underestimated, since under Indian harvesting conditions the grain-straw ratio is likely to be abnormally low. There are also certain other natural fodder resources, such as natural grasses and certain edible shrubs and bushes, which are not included in the above estimate. It will, however, be of interest to determine how far the total nutrients shown in Table 34 would be adequate to meet the requirements for milk production alone, assuming for the moment that the requirements for growing stock and for working cattle could be met from grazing and from these other miscellaneous sources.

India's total output of milk has been estimated at 800 million maunds. The quantities of nutrients required to produce this amount of milk would be 29,550,000 tons of total digestible nutrients and 2,675,000 tons of digestible crude protein(5). According to Table 34 the quantities available are 51,013,000 tons and 2,760,000 tons respectively. It will be noted that while there is an apparent surplus of total digestible nutrients, the quantities of digestible crude protein barely balance. Moreover, it is quite obvious that the assumption regarding the adequacy of grazing lands and other miscellaneous sources to supply sufficient nutrients for both growing stock and working bullocks is untenable. Young stock in particular require large quantities of protein as well as energy for growth. The requirements of working bullocks are also considerable. Estimates collected for the Royal Commission(6) indicate that for about 200 days in each year working bullocks require (apart from grazing) an average of at least 20 lb. roughage per day, and that for half this period they require in addition a supplement of concentrates. It should be emphasised that the period during which there is any considerable growth of herbage on grazing lands is strictly limited : for 3 to 4 months such lands can only be looked upon as exercise grounds, providing indeed an excellent training ground for young draught cattle, but no source of nourishment. In this connexion I was struck by the almost universal demand of the villages for increased grazing land. I do not believe that the grant of such land would alleviate the present shortage of fodder, for the immediate tendency would be to over-graze the areas and leave them barren of herbage within a comparatively short period. Moreover, the provision of additional grazing land could not improve the food supply of the cattle during those months when drought prevents the growth of herbage. In any event grazing under Indian conditions cannot be looked upon as satisfactory source of food for milking cattle.

If milk production is to be increased the provision of a very much larger food supply is essential. The problems involved are two-fold : first, to increase the supplies of fodder suitable for milk production : and second, to ensure that the available supplies are utilised economically. I propose to deal first with these two aspects of

(5) The requirements are calculated as follows :—for maintenance (700 lb. live weight), 0.35 lb. digestible crude protein and 5.6 lb. of total digestible nutrients ; for milk production (5 lb.), 0.40 lb. digestible crude protein and 2.5 lb. total digestible nutrients.

(6) *Loc. cit.*, p. 697.

the subject, basing the discussion on the requirements of total nutrients and of protein. In addition the possibility of a shortage of mineral elements and of vitamins must be considered. This will be dealt with in a separate section.

The need for increased cultivation of fodder crops.

During the past thirty-five years a very marked increase has taken place in the area devoted to green fodder crops, as shown in Table 35. Although the acreage has been more than trebled during this period there is still (as has already been noted) a serious shortage of fodder for cattle. It is significant to note that the present acreage under green fodder crops represents only about 4 per cent. of the total area sown. In Egypt the equivalent figure is over 16 per cent.

The first question which arises is the type of fodder which should be grown. It may be stated categorically that for the necessary increase in the supply of food for milking cattle it is useless to rely on coarse dry fodder. Such fodder contains too little protein in comparison with the total nutrients to be suitable for milk production. For milk production the nutritive ratio(7) of the ration must not be wider than 1 : 10, and the higher the yield of milk the narrower should this ratio be. The nutritive ratio furnishes, in fact, an excellent index by which the suitability of various fodders can be judged. Dry fodders, such as rice straw, and wheat straw, have nutritive ratios of over 1 : 40 and are therefore obviously unsuitable for milk production. Grasses, such as Sudan grass. guinea grass, elephant grass and the spear grasses have nutritive ratios of between 1 : 12 and 1 : 10. These grasses are therefore reasonably good sources of nutrients for milch cattle(8). But the fodders of outstanding value are the leguminous crops such as berseem (Egyptian clover), and lucerne (alfalfa). These fodders have nutritive ratios of 1 : 4 to 1 : 6, and are ideal for milk production. Moreover, they are of special importance to Indian agriculture by virtue of their ability to enhance the fertility of the soil, a point which has already been stressed in Chapter VII.

It is not easy to determine how far such fodders can be produced at a cost which would enable milk production to be profitably undertaken. Figures have been obtained from a large number of experimental and demonstration farms in an attempt to assess the yields and costs of production of typical green fodder crops. Unfortunately these figures not only vary from one locality to another, but differ markedly even in farms situated in the same locality. Moreover many of the crops have been grown on very small areas and under particularly good conditions, with ample manuring and irrigation. It would therefore be useless to attempt to arrive at any average figures for the yields and costs of production. It is, however,

(7) *i.e.*, the ratio between the digestible crude protein and the combined digestible carbohydrates and fats.

(8) Other fodders grown on appreciable areas are *senji* (melilotus parviflora) and shaftal (Persian clover). Green fodder is also obtained by cutting pulses green, and by cutting small quantities of the major crops green for feeding to cattle.

instructive to examine the collected results obtained from all reporting centres It will be seen from Table 36 that the yields from crops of berseem and lucerne are at least as high as those from less nutritious crops such as green *juar* and maize(9) Further, Table 37 shows that the cost of production of lucerne does not differ materially from that of green maize, while berseem can be grown as cheaply as green *juar* If such results can be taken as applicable to most fodder growing areas in India, they constitute a very strong argument for encouraging the growth of these two leguminous fodder crops

I have already stated that wide variations are found in the costs of production of green fodder crops It might be supposed that such variations are due to differences in the methods of cultivation at the various centres It is therefore interesting to note that similar differences are found in the costs of production of green fodders grown on Military Dairy Farms, where conditions of management and cultivation are very uniform The average cost of production on such farms works out at 5½ annas per 100 lb (*i e*, 4½ annas per maund), but the values vary from Re 0 2 11 to Re 1 1 9 per 100 lb, a range of 600 per cent

These facts clearly indicate the need for more careful and extensive investigations into the factors responsible for variations in the yields and costs of production of cultivated fodder crops It would, moreover, be desirable that any such investigations into crop yields and costs should be supplemented by parallel investigations into the value of the different fodders in the feeding of milking stock, particularly in regard to their influence on the cost of production of milk In this connexion reference may be made to an attempt to determine the value of green fodder when utilised for milk production(10) It was found that the addition of 40 lb of green fodder per day to the rations of milking cows increased the milk yield by 45 per cent (*i e*, by 750 lb in a 300 day lactation) If the cost of production of the fodder was assumed to be 3 annas per maund (the nearest average figure which can be taken from Table 37), the added milk yield would have been obtained for an expenditure of Rs 28, or just under 7 pies per lb of milk(11) It is questionable whether this could be considered an economic figure This example serves to emphasise the need for including in any future investigations not only the costs of cultivation of the fodder crops but the effect of feeding these crops on the costs of production of milk as well as their influence on soil fertility

The conservation of fodder crops

During the two or three months immediately preceding the monsoon (and in some areas the period is very much longer) there is no fresh fodder or herbage available for cattle Under present conditions the animals have to subsist during this period on inadequate

(9) The nutritive ratios of green *juar* and maize vary between 1 10 and 1 15 according to the age of cutting

(10) Figures recalculated *from brief*

(11) According to K P R Kartha's figures, the feed cost per lb of milk on Military Dairy Farms varies between 4 and 6 pies

supplies of coarse fodder. If the cultivation of green fodder crops is to be extended it will be necessary to convert part of the produce into a form in which it can be stored for use during the lean months. This point was recognised by the Royal Commission(12), who stressed the value of silage making as a suitable means of conservation. It is disappointing to find that little or no progress has been made in this direction during the intervening ten years. Silage is frequently seen at Government demonstration and experimental farms, but its value appears to be practically unrecognised in the villages. There is an urgent need for popularising this method of fodder conservation among cultivators. If, as appears possible, there are unforeseen economic or practical difficulties in silage making under village conditions, these should be inquired into and where possible remedied. Silage is of such potential value in improving the nutrition of cattle (particularly of growing stock and milking cows) that every effort should be made to encourage its production. As the Royal Commission have stated, " small rations of silage fed to the hungry cows and young stock of the country during the season of fodder shortage would, we think, do more than anything else to bring about a rapid change in the quality of Indian cattle ".

Silage making is not, however, the only feasible method of conserving green fodder. In the hot climate of India it should be possible to devise cheap methods of drying green crops. Such methods would be of special value in irrigated areas, where any surplus green fodder could thus be made available for transport to less fertile areas. Artificial drying is out of the question, not only on account of the high cost of machinery, but because of the heavy costs of maintenance and fuel. Moreover, in a hot and dry climate the employment of artificial methods of drying should not be necessary. There appears to be no reason why green crops should not be sun-dried by methods similar to those employed in Scandinavian countries, for example, by the use of tripods, wedge-shaped hollow frames or spaced poles. Drying under these conditions is extremely rapid, even with relatively 'stemmy' material such as coarse white clovers. The methods are, moreover, simple and inexpensive. There is no doubt that any substantial increase in the cultivation of green fodder crops will necessitate the introduction of improved methods of conservation, and I feel that this offers promising field for study(13).

A further indirect method of conserving the feeding value of fodders (particularly of coarse fodders) is the cutting of the crop at the right stage of growth. This also formed the subject of a recommendation of the Royal Commission(14) who stated " We are

(12) *Loc. cit.*, p. 206.

(13) It should be noted, however, that difficulty is likely to be met through the extreme brittleness of the leaves of crops such as berseem and lucerne. This is referred to in a paper by Wynne Sayer entitled " Berseem as Green Fodder, Hay and Silage ". (*Agric. and Animal Husbandry*, 4, 21 (1934).

(14) *Loc. cit.*, p. 209.

not satisfied that this subject has received enough attention from the agricultural departments, and we would suggest that, in districts in which cattle waste a considerable part of the coarse fodders to which they have access, the possibility of securing a better and more palatable straw by earlier harvesting should be considered, and that experiments should be made to determine the earliest stage at which the crops can be safely cut" These suggested experiments do not appear to have been carried out Nor have any attempts apparently been made to improve natural herbage (either for grazing or for cutting) by the selection of suitable strains of indigenous grasses Both these subjects warrant investigation

Available supplies of concentrates

It would be well at this point to emphasise the need for increasing the available supply of protein rich concentrates such as linseed, cottonseed and earth nut cakes Such concentrates have nutritive ratios of from 1 1 to 1 3 and form by far the most valuable sources of nutrients for milk production The total quantity of concentrates at present available for cattle feeding in India is estimated, according to Table 34, at about 3 800,000 tons In addition to this about 325,000 tons of oilcakes are exported annually from India while the quantity of oilseeds exported amounts to more than 1,000 000 tons If the extracted cake from these two sources could be retained in India, it would result in a considerable increase in the available quantity of protein rich concentrates This subject was discussed by the Royal Commission(15), who pointed out, however, that the only possibility of conserving this valuable potential supply of cattle food was by developing the Indian oil crushing industry In this connexion it would be a sound policy to give active encouragement to the export of vegetable oils since this would indirectly increase the supply of oil cake in the country Improvement in the efficiency of the mills would also tend to lower the price of oil cakes, and so make these products more readily available for the feeding of milch cattle

The rationing of milch cattle

There is little object in attempting to increase the fodder resources of the country unless the available supply can be utilised economically in the feeding of cattle Indian milch cattle are seldom judiciously fed On the one hand cows kept under village conditions are given entirely inadequate quantities of food, while the food used is of the wrong type for milk production On the other hand in well organised city byres the quantity of food fed is frequently as much as 50 per cent in excess of requirements A proper rationing system would tend to correct both these tendencies

It appears to be a fairly universal experience that Western rationing systems are not suitable for application to Indian cattle and buffaloes This is partly due to the lack of information available regarding the composition and digestibility of Indian foodstuffs(16).

(15) *Loc cit*, pp 87—89

(16) J Matson. "Some Lessons learnt in regard to Cattle and Dairying during 25 years' Farming in India" *Journ Cent Bur Animal Husbandry and Dairying*, 2, 145 (1929)

It is also partly due to the fact that Indian cattle and buffaloes appear to have different requirements from European stock; in particular they are credited with a greater capacity for digesting coarse fodder(17). In this connexion it has rightly been pointed out that whereas European cattle have been bred to digest and assimilate the largest possible quantity of food, Indian cattle possess characters which enable them to make the most efficient use of the smallest quantity of food. "The European animal extracting 60 per cent. from 30 lb. of dry matter is inferior *in India* to the Indian animal which can only digest 20 lb. dry matter but extracts 75 per cent.(18)." There is, therefore, a clear need for the formulation of independent rationing standards for Indian cattle.

What has been done to meet this need? Work has been chiefly confined to four centres. At Lyallpur(19) an extensive series of investigations have been carried out to determine the digestibility of various Indian feeding stuffs. An attempt has also been made to find how far coarse fodders, hays and ensiled green crops (alone or in combination) can meet the maintenance requirements of cattle. At Bangalore(20) the work has been largely concerned with the mineral and sulphur metabolism of cattle on various rations including silage. Special attention has been given at this centre to the value of silage as a food for milking stock. At Coimbatore(21) investigations have been made into the protein requirements of working bullocks, while preliminary experiments have been carried out in an attempt to determine the mineral requirements of young dairy stock. At Dacca(22) the work has so far been largely devoted to the formulation of a new method of determining the digestibility of foodstuffs by means of regression equations. The maintenance requirements of bullocks have also been investigated.

Most of these investigations have been carried out with obvious care and by sound methods, and the scientific value of the results cannot be questioned. The broad impression created is, however, that much of the work lacks a practical objective, and that there is a great need for better planned and co-ordinated methods of attack.

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(17) See for example an article by Wynne Sayer [*Agric. and Live Stock in India*, 4, 105 (1934)] in which it is stated that "European equivalents have proved unsuitable for the Sahiwal herd to date, and the alterations in rations and the results achieved point to this fact being of far greater importance than is generally realised."

(18) J. Matson. "Cattle in relation to Agriculture in India." *Journ. Cent. Bur. Animal Husbandry and Dairying*, 2, 83 (1928).

(19) A series of papers by P. E. Lander and associates published as Memoirs of the Department of Agriculture in India and in the Indian Journal of Veterinary Science and Animal Husbandry and other journals, 1927-1936.

(20) Papers by F. J. Warth and co-workers in the Indian Journal of Veterinary Science and Animal Husbandry, and in Agriculture and Live-Stock in India, 1930-1935.

(21) Papers by R. B. Viswanath and P. V. Ramiah, *ibid*, 1933 to date.

(22) M. Carbery and co-workers. "Studies on the Determinations of Digestibility Coefficients." *Indian Journ. Veterinary Science and Animal Husbandry*, 4, 295 (1934) and 687 (1936), and other unpublished papers.

The ultimate objective should undoubtedly be the formulation of a satisfactory rationing system for Indian cattle and buffaloes Before any such system can be worked out it is however, essential to determine accurately the standard requirements for maintenance, growth, work and milk production It is claimed that Indian cattle, and particularly buffaloes can make better use of fodder than European cattle, but no quantitative data are available to show how far this difference depends on more efficient digestion and how far it is due to the better utilisation of the assimilated nutrients Again it is claimed (contrary to a widely accepted view) that work undertaken by draught cattle entails the utilisation of a considerable quantity of protein as well as of energy Until points such as these have been more adequately investigated and elucidated it will be impossible to formulate a satisfactory rationing system Once how ever, such basic information is available rationing becomes relatively easy, since the feeding value of any given food can be determined by chemical analysis supplemented (in certain instances) by digestibility determinations In formulating rationing standards the requirements for maintenance growth, work and milk production will need to be determined in relation to both the energy, protein and mineral constituents of the food Moreover it is quite possible that the requirements will be different for cows and buffaloes and they may even vary for different breeds of cattle The supple mentary study of the digestibility of various classes of feeding stuffs will also need to be undertaken on a fairly extensive scale if reliable average figures are to be obtained which can ultimately be applied throughout India Here also it is possible that the digestibility co efficients will vary according to the type of animal used *i e* buffaloes or oxen

This brief discussion will serve to show the necessity of formulat ing a careful programme of work and of ensuring close co ordination between the various research centres if rapid progress is to be made in devising a satisfactory rationing system for universal application under Indian conditions I would again stress the fact that it is only through the universal adoption of such a rationing system that proper use can ultimately be made of the food resources of the country

I should add one further point At present remarkably few analyses are available of the cattle foods commonly used in India This applies particularly to the various types of dry and green fodder It may be noted, too, that the feeding values of grasses show remarkable variations Thus one authority writes " every thing points to an extraordinary variation in the food values of Indian hay made from the same species of grass grown in different localities and to the fact that grasses which have the best popular reputation have by no means the best feeding value "[16] Side by side with the co ordinated investigation of rationing standards efforts should I consider, be made to obtain representative analytical figures of typical feeding stuffs from as many agricultural areas as possible

Apart from lack of total nutrients and protein in the rations of cattle (which may be the cause of general undernourishment or even of semi-starvation), the lack of mineral constituents and of vitamins may cause pathological conditions in cattle. In some instances these conditions are clinically recognisable, as for example in the bone lesions associated with phosphorus or calcium deficiency. In other instances the abnormal condition is less obvious, and takes the form of a general stunting of growth or an appearance of unthriftiness. It may also result in sterility, or in the premature falling off of milk production.

Nutritional deficiency diseases.

Until recently very little attention had been paid to the possible existence of mineral and vitamin deficiencies among Indian cattle. During the past few years, however, instances of definite deficiency diseases have been recorded. In certain areas in H. E. H. the Nizam's Dominions, for instance, osteomalacia has been found([23]). Again, a condition of blindness in calves has been attributed to lack of vitamin A([24]). Less obvious effects of mineral deficiency have been observed in certain areas of the United Provinces, and have been remedied by the addition of a mineral supplement to the ration([25]). It might be noted, too, that the analyses of fodders derived from different areas show marked variations in mineral content([26]).

There is little doubt that such deficiencies are far more common than has been generally supposed and that they are a source of serious economic loss. Mineral and vitamin deficiencies are, however, relatively cheap to remedy, whether by the addition of mineral mixtures to the food or the soil or by the inclusion of small quantities of green fodder in the ration. It is, therefore, most desirable that extensive surveys of the incidence of deficiency diseases should be undertaken, so that mineral deficient areas can be located and their deleterious effects remedied. At the same time the information gained from such surveys could be usefully supplemented by accurate studies of mineral requirements (such as those noted in an earlier paragraph) and by extensive mineral analyses of fodders drawn from typical cattle breeding and milk producing areas.

([23]) K. C. Sen. "The Nutrition of Indian Cattle. Part II. Malnutrition in relation to Health and Production Capacity of Animals." *Agric. and Live-Stock in India,* 5, 1 (1935).

([24]) K. C. Sen. "The Nutrition of Indian Cattle. Part I. Some Nutritional aspects of Cattle Breeding." *Ibid.,* 3, 549 (1933).

([25]) C. H. Parr. "Some Factors which affect the Supply and Efficiency of Cattle in the United Provinces." *Journ. Cent. Bur. Animal Husbandry and Dairying,* 4, 48 (1930).

([26]) See, for example, A. R. Padmanabha and R. N. Kayasth "Mineral Composition of the Fodders of Central Provinces and its bearing on Animal Nutrition." *Agric. and Live-Stock in India,* 1, 526 (1931), and A. C. Roy and K. C. Sen, "The Seasonal Variation of Lime and Phosphoric Acid in some Hill Pastures." *Ibid.,* 3 (1933).

This might perhaps be a suitable point at which to make very brief reference to another set of pathological conditions which are undoubtedly responsible for the poor condition and high mortality of cattle in certain areas. I refer to parasitic infestations. Although such infestations are not directly related to the nutrition of cattle, they frequently lead to a condition of unthriftiness comparable to that found in cases of serious malnutrition. In view of the heavy economic losses attributable to such parasitic infestations their investigation is urgently called for.

PART III

RESEARCH, EDUCATION AND ADVISORY SERVICES IN CONNEXION WITH THE CATTLE AND DAIRY INDUSTRIES

CHAPTER XI.—Recommendations for the future development of Dairy Research, Education and Advisory Services

Present position

In Part I a general account has been given of the present state of the dairy industry in India. The outstanding impression created by this survey is the entire absence of any systematic investigation of the numerous problems which face the industry, and the lack of a suitable organisation for developing its vast potentialities, either at the centre or in the provinces. Before turning to specific recommendations it is desirable to outline briefly the present organisation.

It may be said that the responsibility for the development of Indian dairying rests almost solely with the Imperial Dairy Expert. This officer, who prior to 1936 was attached to the Imperial Agricultural Research Institute, is now directly responsible to the Department of Education, Health and Lands. His duties, as laid down by the Department[1], include (*a*) the giving of advice to the agricultural and veterinary departments in the Provinces and Indian States and to private persons who are engaged in the production and utilisation of milk; (*b*) the training of post graduate students and of students desiring to qualify for the Indian Dairy Diploma; (*c*) the testing of dairy products for the public where such tests are of a special nature not normally falling within the duties of public analysts and other similar officials; (*d*) the prosecution of research work into problems connected with the dairy industry, including the investigation of methods of handling and transporting milk and the utilisation of milk in the manufacture of milk products; and (*e*) the testing of new types of dairy machinery and equipment.

The office of the Imperial Dairy Expert is at Bangalore, where the Imperial Dairy Institute is situated. His permanent staff consists of two Class II Officers and four Class III Officers. One of these possesses a university degree; the remainder hold dairy diplomas. A farm of 198 acres is attached to the Institute at Bangalore, and there is a small sub-station at Wellington, Coonoor. The Institute itself is used chiefly as a teaching centre. There is somewhat inadequate hostel accommodation for the 24 students who take the dairying diploma, while suitable houses for the staff are lacking. The dairy is small and cramped. The laboratory (which is used for both chemical and bacteriological work) measures barely 20 feet square and possesses practically no equipment. This is supposed to serve for both teaching and research. A portion of an old barn was at one time in use as a laboratory for the physiological chemist[2] and a suggestion has been made that this should be adopted as an extension of the existing laboratory. It is, however, quite unsuitable for this purpose and would not justify the necessary capital outlay. The annual budget of the Institute (i.e., excluding the Imperial Dairy Expert's own budget) is roughly Rs 1,30,000*.

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(1) These are contained in a letter from the Joint Secretary of the Department to the Director of the Imperial Agricultural Research Institute dated 6th April 1936 (No. F. 384/35 A.)

(2) This side of the work has since been transferred to Izatnagar.

*The total budget for the Imperial Dairy Expert Section is at present Rs. 2,65,200.

Facilities in the provinces are even less adequate. Instruction in dairying is included in the courses run by provincial agricultural colleges, but this is of an elementary character. Only one institution[3] has adequate facilities and teaching staff to provide instruction for the Indian Dairy Diploma. No provision is made for research into dairying problems. Any local advisory work in connexion with the production or utilisation of milk is undertaken by the Livestock Experts where provinces include such officers on their agricultural staffs. Otherwise advice has to be sought directly from the Imperial Dairy Expert.

It is obvious from this brief statement that the facilities and staff available at the centre and in the provinces is utterly inadequate to meet the needs of a branch of agriculture of the magnitude of the Indian dairy industry. This fact has recently been recognised by the Central Government, who have given their sanction to an expenditure of some Rs. 6 lakhs to provide additional buildings, equipment and staff. The provisional allocation of this sum allowed for the building and equipment of an Experimental Creamery at Anand (Bombay Presidency) at a cost of Rs. 3¼ lakhs, and for additional accommodation at the Bangalore Institute at a cost of roughly Rs. 75,000. The remaining Rs. 2 lakhs was to be utilised in meeting the recurring expenditure at the Experimental Creamery during the first five years at a net cost of Rs. 40,000 per year. In addition a sum of roughly Rs. 1 lakh has been allocated by the Imperial Council of Agricultural Research for special investigations into problems connected with the manufacture of milk products. A small grant has also been made by the Council to the Allahabad Agricultural Institute for investigations into the chemical composition and physical properties of milk.

The present stock-taking provides an opportunity to re-examine these proposals in relation to the general development of organised dairying in India, and to bring them, if necessary, more into line with the needs of the industry. It would, I believe, be a grave mistake to attempt to meet these needs piece-meal : what is required is the formulation of a co-ordinated and progressive scheme of development which will embrace both research, education and advisory services, and in which both the central and provincial Governments can play their parts.

Since the results of research form the basis of both education and advisory work, this subject will be dealt with first.

I.—Research.

The need for an Imperial Dairy Research Institute.

The number and complexity of the problems which face the dairy industry have been dealt with in the first six chapters of this report. It is obvious that under present circumstances the staff of the Imperial Dairy Institute is not in a position to undertake the scientific investigation of these problems. The

(3) The Allahabad Agricultural Institute.

Institute is at present primarily a teaching centre and does not possess the scientific staff or the necessary laboratory accommodation or equipment for accurate research work. The provision of such accommodation and equipment would involve considerable structural alterations and extensions to existing buildings, but even so the result would not, I believe be really satisfactory. There are, however two more fundamental objections to the existing location of the Imperial Dairy Institute as a possible centre for dairy research. I understand that the site of the Institute was largely selected for two reasons: first because the climate was more equable than in the dairying tracts of Northern India, and second, because there already existed a lucrative market for the milk in the form of the requirements of the military cantonment. Both these considerations adversely affect the value of Bangalore as a centre for research. In the first place the relatively temperate climate is not typical of India's most intensive dairying tracts where the problems of the dairy industry are therefore of a very different character. In the second place the needs of the military are not representative of typical Indian dairying. At present the greater part of the output of milk at the Imperial Dairy Institute is either sold as pasteurised milk or is manufactured into butter or cheese. I have already pointed out that these products are not typical of Indian dairying. It has been urged in favour of Bangalore that the consumption of milk in South India is abnormally low, and that the presence of the Imperial Dairy Institute is of value in stimulating interest in milk production. The Central Government has, however, to consider the needs of India as a whole, and not the special needs of one locality, which is a matter for provincial action.

There is no doubt that the present location of the Institute is largely responsible for the fact that it is seriously out of touch with the real needs of the dairy industry. If (as I have suggested in Chapter II) organised dairying is in future to be largely concerned with the production and marketing of indigenous milk products, it is essential that a more suitable site should be found and that the Institute should be reconstituted as an Imperial Dairy Research Institute. In selecting such a site the following points should be taken into consideration:—

1. The Institute should be situated in a district which is representative of India's chief dairying tracts and of the centres of production of her major dairying product, namely, *ghee*. In practice this limits the site to an area running across the northern part of India and including the dairying belts of Bihar, the United Provinces, the Punjab and Bombay Presidency. The Royal Commission on Agriculture rightly emphasised the fact that the real index of milk production of a province is the number of she buffaloes and not the number of cows. Table 38 shows the cattle densities of the typical dairying districts in the provinces mentioned above. This table shows clearly that the best site

for the new Institute would be somewhere within a triangle drawn through Delhi, Agra and Cawnpore.*

2. I have considered the possibility of both New Delhi and Bareilly as sites for the Institute. Neither of these cities is, however, situated sufficiently close to the *ghee*-producing areas to warrant consideration. On the other hand the selection of a site within the area already mentioned would mean that the Institute could maintain close touch with the Imperial Agricultural Research Institute at New Delhi and with the sub-stations of the Imperial Veterinary Research Institute at Izatnagar. The Institute would also be conveniently near to Aligarh, one of the most important butter making centres of India. Further, the site suggested would be at the centre of the important dairy breeding tracts of India, which extend through the Punjab, Sind, Kathiawar, and the north of Bombay Presidency.

4. It is desirable that the Institute should be situated close to a town having a University or Agricultural College. In this connexion I should point out that the Indian Institute of Science has proved a valuable neighbour to the present Imperial Dairy Institute at Bangalore. It is most desirable that workers at the new Institute should have an opportunity of meeting colleagues of university standing.

5. In selecting the new site it is essential that undue attention should not be paid to the provision of a lucrative market for the milk produced on the Institute's farm. The Royal Commission have pointed out that farms which have been established solely for experimental work cannot be expected to pay their way(4). If the Institute is to undertake the making of indigenous Indian milk products, it is almost inevitable that there will be a considerable financial loss in the running of the farm. Moreover, it is also desirable that the site should be selected solely on its merits and not because land is available in the vicinity which is already owned by Government.

6. Finally, if the Institute is to be located in a typical dairying tract, the climatic conditions will inevitably be exacting. There is, however, no reason why, with modern air conditioning systems, the staff of the Institute should not work under tolerable conditions.

At such a centre the staff would be closely in touch with the industry and with its major problems. There would probably be opportunities of working in collaboration with co-operative societies and other similar associations which might be attempting to improve the conditions of production and handling of milk and milk products

(4) Royal Commission on Agriculture in India, p. 150. Cmd. 3132 (1928).

*See also table 38 (*a*).

in local villages The Institute would also be in closer touch with the Central Government and with the Imperial Council of Agricultural Research at New Delhi(5)

Qualifications of staff

The success of the work of the Imperial Dairy Research Institute will depend very largely on the scientific and technical qualifications of the staff and on their ability to apply their training to the practical problems of the industry I should perhaps clear up any misconception regarding the nature of the work to be undertaken at the Institute It may be thought that this work is of a relatively simple character and that it will not require workers of marked ability It has also been suggested that the dairy industry does not need fundamental research, as its needs are essentially practical Both these views are founded on a complete misunderstanding of the complexity of the problems which await solution I believe that progress in dairy research will only be made in India if it is clearly understood that men are required who, in the words of the Royal Commission "combine scientific knowledge and technique of the first order with the vision and creative power essential to the opening up of new and original lines of work" In staffing the Institute this consideration should be paramount An honours degree in science at a university of repute should, I believe, be regarded as an essential qualification for any of the senior posts at the Institute(6)

The first essential is to secure an able Director, since it is obvious that he will be in a key position in regard to the future development of Indian dairying The Director must therefore be a man of outstanding ability He should have had a wide experience in dealing with the general problems involved in the handling of milk and milk products, he should be capable of initiating and directing research and of relating the Institute's work to the practical problems of the industry It is desirable that he should have had practical experience in the dairy industry as well as a sound knowledge of research methods Above all, he should have the ability to visualise the requirements of the industry and to carry through his projects to a successful conclusion

Under the Director the work of the Institute should, I consider, be divided into four sections, namely, dairy bacteriology, dairy chemistry, dairy technology and dairy husbandry Responsibility for the development of each of these four branches of the work should be delegated to Heads of Sections who should be Class I Officers and who should be given adequate Class II assistants It is possible that in the first instance one or more of these Heads of Sections might have to be recruited from outside India If, however, my later recommendations are agreed to, it should be possible to find adequately qualified Indian workers to fill these posts within a few years

(5) It may be mentioned that the existing institute at Bangalore is over 50 hours journey from New Delhi

(6) *Loc cit*, p 634

As regards dairy bacteriology and dairy chemistry, the Heads of Sections should have had a sound fundamental training in the basic sciences underlying their work. It is essential that the Head of the Dairy Bacteriology Section should also have had a wide experience of the application of bacteriology to practical dairying problems. The Head of the Dairy Technology Section should be selected not so much on account of his knowledge of dairy technology as on his fundamental training in chemical technology and engineering. The future application to dairying of large and small-scale machinery, as well as of refrigeration, will largely depend on his knowledge and ability. He will also be responsible for the testing of dairy machinery and equipment. He should be provided with a capable assistant who has had specialised training in dairy technology.

It is desirable that the Head of the Dairy Husbandry Section should have a special knowledge of Indian dairy breeds as well as of Indian conditions of cultivation. Future policy regarding the breeding of Indian dairy cattle will largely depend on him, and he may also be needed on occasion to advise regarding the official registration of milking breeds. He should be provided with two special assistants, one of whom should be responsible for the accurate costing of both crop and milk production. The other should be a qualified veterinary assistant.

Buildings and equipment.

It has already been stated that the existing Institute at Bangalore possesses entirely inadequate buildings and equipment for research. The new Institute would need fully equipped chemical and bacteriological laboratories, since these sciences form a basis for adequate control in all other branches of the Institute's work. These laboratories would need to be built on a sufficiently generous scale to allow for the accommodation of post-graduate research students. As regards dairy technology, there should be accommodation for small-scale machinery and processing plant. I feel, however, that the arrangements should be as flexible as possible, since the object of this section will be to try out various types of plant and equipment under semi-commercial conditions. The basic needs of this section would be adequate boiler capacity and refrigeration. Some of the dairy plant could be of standard design. Much of it would, however, need to be constructed to meet special requirements. For this purpose it would be essential to have a well equipped engineering shop attached to the Institute. This would also be necessary in connexion with the testing of dairy machinery.

Apart from the above accommodation, the building would need to house offices, a library, and one or two lecture rooms. Separate housing accommodation would be needed for the staff and sufficient hostel accommodation for a small number of post-graduate research students.

As regards dairy husbandry, it is assumed that part of the herds at present stationed at Bangalore would be transferred to the new Institute. It would therefore be necessary to have sufficient acreage to supply fodder for these cattle. Part of the land would

need to be irrigated, and it would be essential to have facilities for running the farm on a 'mixed farming' system Adequate store accommodation would also be needed for accurate rationing and similar experimental work I do not, however, recommend that any metabolism studies should be carried out at the Institute I anticipate that the greater part of the milk produced on the farm would be available for experimental work in connexion with methods of handling liquid milk and of manufacturing milk products Apart from this supply it would be desirable to make provision for establishing one or more experimental depots for the collection and handling of milk under village conditions It would thus be possible to compare the properties of milk produced under ideal conditions with those of milk produced under village conditions This would be of great value in determining the feasibility of the adoption of new methods of processing and manufacture

The need for an experimental creamery

In considering the building and equipment of the new Research Institute, the question at once arises, whether it would also be necessary to proceed with the building and equipment of the proposed experimental creamery at Anand This scheme was originally put forward for three reasons first, to provide a centre for research and training in factory dairying, second, to enable such work to be carried out under the climatic conditions experienced in typical Indian dairying tracts, and third, to study the problems involved in the supply of liquid milk to large cities So far as the first point is concerned, it is obviously unjustifiable, in view of the arguments put forward in Chapter II, to spend large sums on the manufacture of products which are of relatively little importance in India Regarding the second point, if the new Institute is placed in the area which I have suggested it will be subject to the same climatic conditions as at Anand There remains the third point, namely, the supply of milk to large cities I have already pointed out that only a very small proportion of India's population live in large cities The provision of adequate supplies of milk to mofussil towns is, in practice a more important subject for study If, however, the problems involved in supplying milk to large cities are to be investigated, Anand would be an ideal sub station for the purpose But its establishment as a sub station would result in considerable duplication of equipment and staff Under the circumstances I suggest that the whole of the Anand proposals should be held over until the new Research Institute has been satisfactorily established and preliminary experiments have been carried out on the various problems involved in dealing with liquid milk It will then be easier to determine whether or not a sub station will be necessary at Anand

Expenditure involved

It is not possible at this stage to suggest any definite figure for either the non recurring or the recurring expenditure which is likely to be involved in the establishment of the proposed Imperial Dairy Research Institute It is, however desirable to give some general indication of the probable financial needs

As regards non-recurring (capital) expenditure, it may be noted that a sum of Rs. 6 lakhs has already been sanctioned in connexion with the Anand scheme, although only Rs. 4 lakhs were provisionally allocated for capital expenditure at Anand and Bangalore. I recommend that the whole of this sum of Rs. 6 lakhs should be allocated for capital expenditure in connexion with the new Research Institute. In addition any sum realised from the disposal of the Bangalore and Wellington farms [which were taken over from the Military Authorities at a total valuation of Rs. 2,84,000(7)] should be made available towards the purchase of land for the new Institute.

As regards recurring (annual) expenditure, it is extremely difficult to give even a rough estimate. It is probable that the pay of the senior staff would amount to roughly Rs. 1½ lakhs per year and on this basis it may be assumed that the total budget for the Institute would be between Rs. 2½ and 3 lakhs. It would probably be necessary to add a further sum in order to offset any losses incurred in the running of the farm. It may be noted that the annual sum spent on the running of the two national centres for dairy research in Great Britain is considerably greater than this sum (8), although the British dairy industry handles only a quarter of the quantity of milk produced in India.

At present very few investigations into dairying problems are undertaken at provincial agricultural and veterinary colleges. This is perhaps partly due to the lack of adequate staff and facilities available at these provincial centres. But it is, I believe, largely the result of concentrating dairy education and advisory work at the central Institute at Bangalore : provincial Governments are apt to overlook their responsibilities in this direction, and this in turn means that no active encouragement is given to workers at provincial centres.

Dairy research in the provinces.

In a later section I recommend that advanced instruction in dairying should be given at the provincial colleges instead of at the central Institute, a recommendation which was indeed put forward by the Royal Commission on Agriculture, but which was not implemented(9). It is, however, equally important that these colleges should be encouraged to undertake research into local dairying problems. A central research institute cannot undertake the study of problems of purely local interest, nor can such an institute investigate all the factors which may have to be taken into account in applying any new method under the wide variety of conditions existing in India. It is therefore essential that adequate research facilities should be provided at the various provincial colleges, and that one

(7) The amounts paid to the military authorities on the transfer of the Bangalore Institute to the Imperial Agricultural Department were as follows :—lands, Rs. 22,953 ; buildings, Rs. 1,36,773 ; plant and furnishings, Rs. 27,102 ; live-stock, Rs. 55,954 ; stocks, Rs. 41,344 ; total, Rs. 2,84,126.

(8) State grants to the two institutes total over Rs. 3½ lakhs, while a further Rs. 1 lakh is received from other sources.

(9) *Loc. cit.*, p. 247.

or more specially qualified workers should be available to undertake the necessary investigations

I consider that this is one of the directions in which valuable assistance might be given by the Imperial Council of Agricultural Research The financial needs of the central institute should normally be met by direct grants from the Department of Education Health and Lands, and the Institute should *not need to seek* financial assistance from the Council The provision of grants from the Council would however, form a useful means of encouraging the development of dairy research in the provinces and constituent states As a first step the Council might consider making special grants to those provinces which are willing to provide facilities for advanced dairying instruction A special grant to meet the cost of purchasing additional equipment and recurring grants *towards the costs of* special investigations into certain dairying problems have already been made to the Allahabad Agricultural Institute This might be taken as a useful precedent The nature of the problems to be investigated would, of course depend on local requirements, though a number of suggestions have been put forward in Chapters III to VI As the work of the central institute developed it would obviously be desirable *to arrange* for close collaboration between workers at the centre and in the provinces In this field also the Council could play a very useful part

In the meantime the Council has (as I have already indicated) sanctioned a grant of Rs 1 lakh for the study of problems concerned in the production of condensed and dried milks If, as I have recommended the Anand experimental creamery scheme is abandoned, this sum could be released for work along other lines I do not think that it would be better utilised than in initiating research work at provincial centres along the lines just discussed

II —EDUCATION

At present advanced courses in dairying are given at two centres, *namely*, at the *Imperial Dairy* Institute at Bangalore and at the Allahabad Agricultural Institute The standard course is that leading to the Indian Dairy Diploma This is a two year course with a syllabus somewhat similar to that of the National Diploma in Dairying of Great Britain It is designed to give the student sufficient knowledge and experience of practical dairying to enable him to undertake the responsibility of managing a dairy herd *or of running a small dairy* Proposals are at present under discussion for making this course a more advanced one These proposals include the provision of special instruction in dairy factory management, and necessitate the extension of the period of training by an extra year

Introduction

Apart from this course the Imperial Dairy Institute accepts post graduate students for a 15 months' special course This consists partly of training on the lines of the dairy diploma and partly of research though the facilities for the latter are at present quite

inadequate. In addition occasional short courses of practical instruction and vocational courses for British troops are run at Bangalore.

At the provincial agricultural colleges there are no advanced courses in dairying. The college degree courses include instruction in dairying. Special short courses in elementary dairying are also run from time to time. At Lyallpur and Nagpur there is a six months' vernacular course. At Poona special courses are run whenever there is a demand for them ; these are of variable length. At Coimbatore elementary dairying is included in a special short course in agriculture. At provincial veterinary colleges the instruction in dairying is (with one exception) meagre, and is usually limited to a short course in milk inspection. Most veterinary colleges are, however, handicapped by the lack of a milking herd or dairy, so that instruction is carried out under very unfavourable conditions.

As a result of my inquiries I consider that three types of dairy training are required, namely, instruction in general dairying, post-graduate training in research methods, and elementary courses in practical dairying.

Instruction in general dairying.

There is no doubt that the existing I. D. D.[10] course fills a definite need. This may be judged in two ways. In the first place there is an encouraging demand for admission to the course. The number of enquiries received at the Bangalore Institute during the past three years has been 128, 295 and 310 respectively, although a total of only 45 students could be admitted owing to the very limited accommodation. Similar figures are not available for the Allahabad Institute, but I am informed that the course is invariably full. In the second place I am told that successful students seldom fail to find employment. Unfortunately complete figures are not available on this subject. At least 63 students are known to be in employment[11]. In view of these facts I consider that the course of training for the I. D. D. should be retained as the main course of instruction in general dairying. Two obvious questions arise : first, whether the syllabus of the course requires amendment, and second, what future provision should be made for the teaching of I. D. D. students.

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(10) Indian Dairy Diploma.

(11) It is interesting to note the division of employment between government service and private dairies :—

	Number.	
Central Government	11	
Provincial and State Governments ..	26	
Military Dairy Farms	4	41
Private dairies, etc.	..	20
Higher studies	..	2
		63

The proposal to increase the existing I D D course from two to three years is based on two arguments, first, that at their time of admittance many students are not sufficiently well educated to be able to complete the course satisfactorily in two years, and second, that the course ought to include advanced instruction in dairy factory management

Syllabus for the Indian dairy diploma

As regards the first point the official reports of examiners repeatedly stress the fact that many students show a very poor command of English Under normal circumstances only matriculates are admitted to the I D D course exemption from matriculation is stated to be given only under exceptional conditions Reference to the admissions to the Allahabad Agricultural Institute shows however, that 10 per cent of those accepted are non matriculates It appears, therefore that the examiners' complaints regarding the lack of general education among students could be easily remedied by tightening up the standard of admission

As regards the second point namely, the inclusion of advanced instruction in factory management this is based on the assumption that Indian dairying should be run on Western lines I have already expressed the view that the adoption of the so called factory system of dairying is not applicable to Indian conditions of production I have also shown that even if it is feasible to establish large factories for the manufacture of such products as condensed and dried milks, three or four such factories would be sufficient to provide for the full needs of the existing market Openings for employment in such factories would therefore be very limited Moreover, inquiries among firms who might ultimately establish factories in India reveals the fact that such firms invariably train their own employees in factory methods of production what they require before engaging such employees is a general knowledge of dairying and of the sciences underlying dairy practice

Under these circumstances I do not consider that any useful purpose would be served by lengthening the period of training for the I D D or by including in the syllabus advanced training in factory processing or management General information on this aspect of dairying can more readily be given in lectures supplemented, if desired by brief visits to modern butter making creameries and other specially equipped centres [12]

As regards other subjects included in the I D D syllabus I do not feel that any drastic alterations are called for If candidates can answer satisfactorily the type of examination paper which I have been shown, they must have attained a satisfactory standard of both theoretical and practical training I am somewhat apprehensive that too great stress is laid on butter and cheese making The value

(12) For example, visits might be arranged to such centres as the Dayalbagh Dairy, the Military *Ghee* Heating Centre at Agra, and the Imperial Dairy Research Institute

of the separator method of butter-making as against the 'country' method for the ultimate production of *ghee* has yet to be demonstrated. Cheese-making is of negligible importance in Indian dairying. I feel that more stress should be laid on the methods of production of indigenous milk products, on the need for devising cheap types of equipment, and on the improvement of methods of producing milk and milk products by co-operative enterprise and by the development of village industries. Instruction along these lines is at present handicapped by the lack of available knowledge on the subjects in question. This difficulty will disappear as further knowledge is acquired.

There is, however, one other aspect of the training which, I believe, requires special emphasis. The training should include adequate practice in the methods of imparting instruction in dairying in both English and the vernacular. Holders of the I. D. D. will probably be largely responsible for introducing improved dairying methods into village practice, either by the running of elementary dairy courses or by organising village collecting centres and other co-operative enterprises. In such work it is essential that the man in charge should be capable of presenting his subject in a clear and convincing manner. The I. D. D. course provides an excellent opportunity for instruction and practice in this subject.

I have been somewhat disturbed to find that a comparatively small number of graduates take the I. D. D. course. This is largely due to the fact that the Bangalore Institute run a so-called post-graduate course in addition to the I. D. D. course. Since 1924, 45 students have taken the post-graduate course, compared with 150 who have taken the I. D. D. course. It appears to me to be unnecessary to run a special course for post-graduates. The present post-graduate course is a combination of advanced instruction in dairying and training in research methods. I do not think that these two aspects of dairying can be satisfactorily included in a single course. As regards research, I am recommending the provision of suitable facilities at the new Research Institute. As regards advanced instruction in dairying, I consider that the present I. D. D. course should meet the normal requirement. It is, however, desirable to consider how far graduates in agriculture might be given special encouragement to qualify for the I. D. D. by exemption from some part of the two-year course. Under existing circumstances I do not think that this proposal would be feasible. But if (as I recommend) the I. D. D. course is to be included in the normal curricula of provincial agricultural colleges, there seems no reason why the dairying training for the agricultural degree should not be dovetailed with that for the I. D. D. An examination of the syllabuses of the I. D. D. and of typical agricultural degree courses shows, in fact, that there is already considerable duplication in the subjects studied. I do not consider that any similar exceptions could be given to veterinary graduates, whose training does not include subjects such as crop husbandry and farm management.

At present instruction for the I D D is only given at two ntres, namely, at Bangalore and at Allahabad If my recommendations regarding the transfer of the Bangalore Institute to a new site and its establishment as an Imperial Dairy Research nstitute are adopted, the question will arise whether I D D. courses hould be run at the new centre In this matter I strongly support he recommendation made by the Royal Commission on Agriculure(9) that advanced dairying instruction should be undertaken at provincial agricultural colleges and not at the central institute There are a number of reasons for this proposal The present accommodation at Bangalore is entirely inadequate to meet the demand for admission to the course(13). If the new Institute were to undertake the instruction of I D D students, it would entail a very heavy capital expenditure on additional laboratories and equipment and on hostel accommodation The staff would also need to be increased On the other hand provincial agricultural colleges already possess teaching laboratories and equipment, and have, I understand, adequate hostel accommodation They have a full complement of lectures on those general scientific and agricultural subjects which are included in the I D D syllabus The equipment of the dairy departments would undoubtedly need to be augmented, and increases would probably also be necessary in the dairy staffs The provision of such additional equipment and staff would, however, tend to improve the dairying instruction for agricultural degree courses, in addition to catering for the I D D course I have already stressed the need for stimulating the interest of provincial Governments in the development of dairying The transfer of the I D D training to provincial colleges would, I believe, go far towards achieving this aim There is, too a further point I have found that there is a definite tendency to discriminate between students trained at the Imperial Dairy Institute and those trained at the Allahabad Agricultural Institute, not on account of any difference in the efficiency of the training, but because training at the Imperial centre gives a better ' hall mark to the student This attitude is unfortunate but, I believe, inevitable so long as the Central Government provides facilities for the course at its own institute

Centres of instruction

It is very doubtful whether the training of I D D students could meantime be satisfactorily undertaken at all provincial agricultural colleges It is indeed questionable whether such a wholesale transfer of work would be desirable until more experience has been obtained regarding the possible difficulties involved I suggest that under the circumstances the number of centres should meantime be limited I assume that the Allahabad Agricultural Institute will remain as one centre Geographically it would seem that at least two other centres would be required, one in Northern India (say Lyallpur) and one in Southern India (say Coimbatore) Such centres might be given financial aid by the Imperial Council of Agricultural Research on the lines already adopted in regard to the Allahabad Insti-

(13) As stated in a previous section, only 45 students have been admitted during the past 3 years, during which over 700 inquiries have been received

tute. The possibility of extending the arrangements to include other provincial agricultural colleges should be considered in the light of the results achieved at these centres.

The transfer of instruction for the I. D. D. would, however, necessitate the adoption of certain safeguards. These may be summarised as follows :—

(*a*) There should be not only a uniform syllabus for all centres, but a reasonable degree of uniformity in the methods of teaching. It would also be essential for the course to include adequate practical training in farm operations as well as in dairying. These points have been repeatedly stressed in examiners' reports.

(*b*) The criticism has been made in examiners' reports that the present I. D. D. instruction at the Allahabad Agricultural Institute is handicapped by the lack of coordination between the teaching in the dairy department and that given in the pure sicence departments, the implication being that the teaching in pure science is not adjusted to the special needs of the I. D. D. course. This matter is obviously one which would need to be considered in drawing up the detailed scheme of training at each centre. It may be mentioned that in Great Britain it is the universal practice for N. D. D. students to receive part of their instruction in pure science departments, and the system works satisfactorily.

(*c*) It would be necessary for the I. D. D. course to be run according to college sessions and not (as is done at present) by calendar years.

(*d*) It is essential that the examination for the I. D. D. should be of the same standard at each centre. For this purpose a central examining board would be required.

(*e*) For the appointment of the examining board, as well as to settle all points of common interest, such as the syllabus and methods of instruction, a special committee should be constituted under the Imperial Council of Agricultural Research. This committee would also be responsible for recommending new centres, and for reviewing the standard of teaching and the facilities available at existing centres. The committee should include one nominee from each recognised centre as well as members appointed directly by the Imperial Council. It should meet at least once each year, preferably immediately after the annual examinations, so that the examiners' reports could be submitted and any necessary action taken. The committee should be responsible

for printing and publishing the syllabus, which should also include brief notes on the facilities available at each centre

At present there are two avenues open to graduates who require [ad]vanced training in dairying, namely to take the so called post-graduate course at the Bangalore Institute, or to go to Great Britain in order to take the course for the National Diploma in Dairying

[P]ost graduate train[ing] in research

As regards the N D D course in Great Britain, I consider that [th]is is entirely unsuitable for Indian students The N D D course [is] based on a study of British farming conditions and of British [d]airy products such as butter and cheese Indian students who [q]ualify for the N D D return to India with, I believe, entirely er[r]oneous views regarding the possible application of Western dairy[i]ng methods to Eastern conditions This is likely to do the Indian [d]airy industry more harm than good

As regards the existing post graduate course, it has already been stated that this is largely a duplication of I D D training, and could quite well be amalgamated with the I D D course The I D D forms an excellent basis for practical dairy training, and if an agricultural graduate possesses the I D D in addition to his degree he should be well qualified to fill any post in the educational or advisory services or in the commercial field There are, however, very few Indian graduates who are qualified to undertake research work in dairy science In such work a detailed knowledge of technical dairying is a secondary consideration The research worker needs to have a thorough training in scientific methods of investigation and a fundamental knowledge of one or more branches of pure science Such a man can readily acquire the necessary acquaintance with dairy practice without extensive practical training It is significant to note that an essential qualification for agricultural research workers in Great Britain is an Honours degree in science and that the Royal Commission on Agriculture recommended the adoption of this standard in the recruitment for research posts in the Indian agricultural services([14])

I am convinced that little real progress will be made in the solution of Indian dairying problems until a nucleus of specially trained graduates is available to undertake the necessary scientific investigations It is here that benefit should be derived from the establishment of a properly equipped Dairy Research Institute since part of the work of such an institute should be the training of science graduates in research methods Moreover, opportunity should be taken to encourage such graduates (preferably after a period of study at the central research institute) to gain further experience by studying at recognised research laboratories abroad The objection to foreign training in dairying which was noted earlier in this section does not extend to training in research since the latter involves a general study of the application of scientific principles and

(14) *Loc cit*, p 634

technique to the solution of dairy problems, and not merely a specialised knowledge of dairying practice.

If science graduates are to be encouraged to enter this field of study, certain incentives will, I think, be necessary. In the first place it is essential that such post-graduate research students should be able to work for higher university degrees at the Imperial Dairy Research Institute. This arrangement was suggested by the Royal Commission(15) in regard to post-graduate students working at the Imperial Agricultural Research Institute. It should, I think, apply equally to the dairy research institute. In the second place it is desirable that funds should be made available to enable research scholarships to be awarded to promising science graduates to enable them to work at the central institute or to reside at a foreign research centre for an adequate period of training. The provision of such scholarships might be undertaken by the Imperial Council of Agricultural Research(16). In the third place it will be valueless to give initial encouragement of this nature to promising students unless a real attempt is to be made to establish a research service for the dairy industry commensurate with its importance in Indian agriculture. I have already referred to the need for developing dairy research in the provinces. This will inevitably be a gradual process, but I anticipate that it should proceed with sufficient rapidity to absorb the specially trained scientific workers who will become available during the next ten or fifteen years.

Elementary dairy training.

If improved methods for the production and handling of milk and the manufacture of milk products are to be made use of in the villages, it will be essential to have available a large number of workers trained in certain elementary dairying practices. Such workers might be responsible for running village collecting or separating centres, for *ghee* or *khoa* making on a village industry basis, for the supervision of *mandies*(17) or for running small retail milk shops. Such men would need elementary training in dairy hygiene and specialised training in the particular branch of work which they are to undertake. They would, in fact, correspond to the 'stockmen' who are already employed in certain branches of animal husbandry and veterinary work. Short vernacular courses would be necessary for the training of such men, but the syllabus of these courses should be elastic, being altered from time to time to meet the immediate needs of the dairy industry. The training would, of course, need to be undertaken at provincial centres, and successful trainees might be awarded a special college certificate. It would be desirable that the syllabus for such courses should be discussed with the Imperial Council of Agricultural Research, which could act as a valuable clearing house for information on the subject.

(15) *Loc. cit.*, p. 60.

(16) The scholarships offered by the Agricultural Research Council of Great Britain usually allow for two years work at home and a third year abroad.

(17) *i.e.*, *ghee* collecting depots.

In any such work I strongly recommend that serious consideration should be given to the provision of dairy training for women Women have a natural aptitude for dairy work moreover, they are already largely responsible for the handling of milk and the manufacture of milk products such as *ghee* If improvements are to be effected in the handling of milk and milk products under village conditions the cooperation of the women of the village is essential In any attempt to provide special dairy training for women I suggest that collaboration should be sought with other agencies such as the health services, co-operative societies, and philanthropic and welfare associations

The dairying instruction given at veterinary colleges is at present usually limited to a short course in milk inspection It is very desirable that this instruction should be extended to include a knowledge of elementary dairying and of the principles involved in the production and handling of milk, including the management of a dairy herd The veterinary assistant is brought into close contact with the cultivator and a better knowledge of dairying would frequently enable him to influence the latter in adopting improved dairying methods The responsibility for this side of the work will tend to increase if as I recommend later, the animal husbandry and veterinary services are unified It is therefore all the more important that adequate instruction in dairying should be included in the syllabus of veterinary diplomas and degrees The inclusion of such training will necessitate the provision of adequate accommodation for a small dairy herd and dairy at each veterinary college and it is possible that the staff will also need to be augmented at some centres by the inclusion of a qualified instructor in dairying

Courses of instruction at veterinary colleges

III —Advisory services

In Part I of this Report I have pointed out that very little is known regarding the best methods for the production and handling of milk and the manufacture of milk products under the tropical conditions of India It might therefore appear doubtful whether the time is yet ripe for constituting dairy advisory services in the provinces This would, however, overlook two facts

Present position.

In the first place the Imperial Dairy Expert is at present the only officer available in India to answer the large number of inquiries which come from all parts of the country *Owing to the* time *and* expenditure involved in *travelling* the Imperial Dairy Expert is only able to answer these inquiries by correspondence He is, moreover, seldom in a position to know the local conditions of production and the local market requirements *Consequently* he has to rely on the information—often incomplete or even misleading—which he is given by his correspondents I found on more than one occasion that this had resulted in the installation of plant and equipment which was entirely unsuited to the local conditions,

and that in consequence there had been serious financial losses as well as loss of confidence. The Imperial Dairy Expert himself quoted an instance where a timely visit had put an entirely different complexion on a new dairying enterprise and had enabled him to reduce the proposed capital expenditure from a very large sum to a few hundred rupees. If a local advisory staff was available in each province, such difficulties would not arise.

In the second place it is clear that an officer such as the Imperial Dairy Expert cannot take any active part in stimulating the development of dairying in the provinces. Most provinces are at least as large as Great Britain and it will be readily understood that the services of a special provincial staff are essential if the needs of such large areas are to be explored and their potentialities developed. Such a provincial staff would, moreover, not only be in a position to give expert advice both to the provincial government and municipalities, but would be available as the medium for initiating any new schemes of development which might be planned.

Need for a provincial service.

Under these circumstances I strongly recommend that provincial governments should take the necessary steps to establish an advisory service for the dairy industry. As a first step I consider that a specialist officer should be appointed in each province. This officer could undertake a preliminary survey of the needs of the province. Further development would depend on the results of his survey : whether, for example, progress could best be achieved by organising village milking centres, or by encouraging the co-operative production of milk products, or by the establishment of grading centres and other improved methods of marketing. It is essential that the specialist officer should not merely look on his post as that of an expert adviser. His major duty should be to initiate developments, and to take the lead in encouraging the adoption of improved dairying methods. For this reason I suggest that his official designation might be that of "Dairy Development Officer".

Methods of securing co-ordination.

The question at once arises as to the department to which this officer should be attached and as to the means which should be adopted for keeping him in touch with the centre. In this connexion I have been greatly impressed with the organisation of the agricultural marketing staff. Provincial Marketing Officers, while nominally attached to agricultural departments, actually work under a small committee representative of the various departments and interests concerned. As regards contact with the centre, arrangements are made by which close touch is maintained with the Agricultural Marketing Adviser to the Government of India, and all marketing surveys are co-ordinated through this channel. I consider that a somewhat similar arrangement might be adopted in regard to the administrative position of the Provincial Dairy Development Officers.

The development of dairying is closely related to many other hes of government activity I suggest that the committee - which the Dairy Development Officer should work should ide the Director of Agriculture, the Director of Veterinary ices, the Director of the Public Health Department, the Re- ar of Co operative Societies, the Provincial Marketing Officer, not more than three other members who should be nominated account of their special interest in some aspect of dairying(18). of these should be a member of the dairy staff of the provincial cultural college This arrangement would ensure the co- ination of dairy developments with Government activities in ely allied fields, and would provide the Dairy Development cer with a valuable source of advice and assistance in the plan- g of his work*

Co ordination with the central Government involves a more nplex problem The development of dairying in India is primarily the concern of provincial Governments Owing to the very undeveloped condition of the industry it is, however, ential that the central Government should take a prominent part initiating and co ordinating any developments I have already commended the establishment of an Imperial Dairy Research stitute as the main contribution which the central Government in make to the development of the dairy industry It is, I believe, ually important that the central Government should encourage he exchange of ideas and experiences among Provincial Dairy Development Officers and also between such officers and the staff f the central Research Institute The obvious channel for such o ordination is the Imperial Council of Agricultural Research One nethod of achieving this aim would be to attach a specialist officer o the Council whose duties would include the co ordination of dairy levelopments and of dairy research in the provinces I believe, however, that the purpose in mind could be achieved more efficiently and economically by combining these duties with those of the Director of the Imperial Dairy Research Institute The Director should be the best qualified worker in this field in India He will be in intimate touch with the latest research work at his own institute as well as at other research centres in India and overseas For the successful planning of the Institute's programme of work he should, moreover, be kept closely in touch with the needs of the Indian dairy industry, and this could be assured if he has facilities for maintaining personal contact with the Provincial Dairy Development Officers

Co ordination with centre

For administrative reasons it is, however, essential that the actual channel of communication should be through the Imperial Council of Agricultural Research I suggest, therefore, that the

(18) See, however, the suggestions put forward in Appendix VI

*The actual executive control of the Dairy Development Officer might be entrusted to the Head of the Department responsible for animal husbandry development.

Director of the Institute should not only be appointed a member of the Council, but that he should act as part-time Dairy Expert to the Council in so far as his duties include those of advising and co-ordinating work in the provinces and constituent states. The transfer of the Institute from Bangalore to a site nearer to New Delhi will facilitate this arrangement. I should make it clear that this proposal is not intended to prejudice the ultimate appointment of a full-time Dairy Expert to the Council if the growth of organised dairying should justify this step. The suggested arrangement would, however, supersede the present post of Imperial Dairy Expert.

I should perhaps state at this point that I feel that the relationship between the Imperial Council of Agricultural Research and the three Imperial Research Institutes(19) requires clarification. The functions of the Council are not limited to the promotion, guidance and co-ordination of agricultural and veterinary research. The Council is also designed to act as a clearing house of information in regard to agricultural and veterinary matters generally(20). In this respect it stands in a unique relationship to provincial Governments, and it is therefore the obvious body through which co-ordination and the exchange of ideas and experiences should be secured. But I believe that it is equally important that the Council should be able to make full use of the special facilities available at the Imperial Research Institutes, and that the programme of work of these Institutes should be subject to periodic review by the Council. Ultimately it may be desirable to establish a more direct relationship between the Council and the Imperial Research Institutes on the same broad lines as that which exists between the Council and the recently established Imperial Institute of Sugar Technology. In the meantime the appointment of the Director of the Imperial Dairy Research Institute as part-time Dairy Expert to the Council will ensure a very close measure of collaboration between these two bodies.

If this additional duty is to be undertaken by the Director of the Institute it is essential that he should be provided with a special officer who can relieve him of much of the detailed work involved, and who can act as a personal liaison officer between the centre and the provinces. Such work will probably involve considerable travelling, since one of its objects will be to assist Provincial Dairy Development Officers in the initiation and development of new methods of handling milk and milk products. It is obvious that the Director cannot undertake this work personally. It is desirable that, in addition to an extensive knowledge of the dairy industry, the officer appointed should have had experience in similar organising work, preferably in connexion with the supervision of provincial marketing inquiries.

(19) *i.e.,* the Imperial Agricultural Research Institute, the Imperial Veterinary Research Institute, and the Imperial Dairy Research Institute.

(20) Memorandum of Association of the Imperial Council of Agricultural Research.

I should, perhaps, refer briefly to the probable costs involved in the establishment of dairy advisory services in the provinces The initial expenditure should not exceed, say, Rs 25,000 per year in each province, which would meet the salary and expenses of the Provincial Dairy Development Officer, with perhaps one or two assistants The ultimate expenditure would considerably exceed this sum, but would probably not be in excess of Rs 1 lakh per year It is instructive to compare this with the expenditure involved in the dairy advisory services of Great Britain The total number of county instructors and other advisory officers employed is 125, and the expenditure *on salaries alone* is roughly £30,000 (Rs 4 lakhs) *Yet the value of Great Britain's output of milk is only about a quarter of that of India* Moreover, in India the provision of Government assistance is far more urgently required than in Great Britain, owing to the backward state of the Indian dairy industry If the establishment of provincial advisory services resulted in an increase in the value of milk products by only one tenth of one per cent of its present value, the sum realised (Rs 30 lakhs) would be far more than sufficient to justify the whole of the administrative expenses involved

Probable expenditure involved

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CHAPTER XII.—Recommendations for the future development of Research, Education and Advisory services in connexion with cattle improvement.

In Part II a description has been given of the efforts which are being made to improve the general standard of Indian cattle, and attention has been directed towards some of the major problems to be solved and some of the more urgent difficulties to be overcome in achieving this end. The present chapter will be devoted to specific recommendations in connexion with the future development of the cattle industry. As in the previous chapter, the subject will be dealt with under three heads, namely research, education and advisory services.

I.—Research.

The existence of a number of large Government breeding farms in India offers unique facilities for the study of problems of inheritance in cattle. It is therefore somewhat surprising to find that no notable contributions to existing knowledge have been made in this field by workers in India. I believe that this is largely due to the fact that there has in the past been no focussing point for such work. The breeding farms have been run on strictly utilitarian lines; unsatisfactory animals have been "culled" and no serious attempt has been made either to record the full breeding data of the herds or (where such data have been recorded) to analyse the results systematically. Thus the opportunity of collecting and analysing information of great potential value has been neglected. As a first step in remedying this position it is, I believe, essential that a first-rate geneticist should be recruited for service in India. I have been particularly struck by the valuable results achieved by geneticists in plant breeding, and I do not doubt that equally valuable (though less rapid) results might be achieved in the field of animal breeding. I understand that proposals are already under discussion for the establishment of an animal genetics section of the Imperial Veterinary Research Institute at Izatnagar. I believe that such a section would prove to be a great asset in the future development of cattle breeding in India(1).

Problems of breeding and management.

Work in this field may be classed under three heads: problems associated with inheritance, problems involving a study of the physiology of reproduction (including endocrinology), and problems connected with management and constitution.

As regards problems of inheritance, there is no doubt that these can best be investigated in collaboration with existing cattle breeding farms. In the study of the inheritance of milking capacity, the lack of any uniform system of milk records—indeed the

(1) The Royal Commission on Agriculture in India (Cmd. 3132, p. 242) expressed the view that the time was not ripe for the establishment of an animal genetics institute in India, and stated that much valuable work in cattle breeding might be done without such a centre. Their arguments apply, however, only to research into specific problems of inheritance; they do not apply to the relatively modern developments which are now included under the general heading of genetics, namely endocrinology and the physiology of reproduction.

The provision of milch cattle suitable for hill districts does not involve any serious difficulty It is found that European breeds thrive well under the temperate conditions of climate Indigenous Indian breeds are also found in some districts,—for example the Siri breed in Darjeeling and the Lohani breed in the North West Frontier Province European cross breds are commonly found, but it is stated(5) that this is having a detrimental effect on the draught qualities of local stock Scindi cattle and buffaloes also appear to thrive well I should, however, mention that in certain areas there is a high incidence of hæmaturia among cattle, which is a source of considerable loss to owners of stock

A more difficult problem is the provision of an adequate supply of fodder for milch cattle It is impossible to generalise on this subject, owing to the wide variations in climate, elevation and contour at different hill stations At Coonoor and Ootacamund, in the Nilgiri Hills the cattle are able to graze on the rolling down land which forms the main plateau Green crops such as oats can be grown successfully in such localities On the other hand in the more typical hill stations such as Simla and Darjeeling, fodder has to be obtained from forest areas In these districts there is a serious shortage of fodder suitable for milking stock and particularly of grazing land Cattle owners are therefore encouraged to stall feed their stock, the Government having, for example, built cattle sheds at Darjeeling for the purpose(5) While certain crops such as maize can be grown, reliance has to be largely placed on the use of local shrubs and scramblers for fodder Efforts are being made to develop the planting of fodder trees which stand annual or periodic lopping It is claimed that such trees produce more leaf fodder than could be produced from the same area of fodder grasses(6) Experience shows, however, that the control of such lopping is essential in order to prevent permanent damage through injudicious lopping by ignorant *gujars* It is interesting to note that, where uncontrolled lopping has been permitted, the deterioration has been so serious that the local inhabitants have petitioned for control by the Forest Department or have introduced their own methods of control in order to conserve the available supplies of fodder It is clear from these brief notes that forest departments are already taking active steps to augment the supplies of fodder in hill areas I consider that such work is of great value not only in improving the condition of the cattle but in cheapening and increasing milk production

(5) F Canning "Notes on the Better Utilisation of Forest Areas for Grazing" New Delhi, 1936

(6) F A Smythies, Conservator of Forests Western Circle U P (quoted by F Canning)

APPENDIX IV.—The Provision of Milk for Children of School Age.

I have already referred in Chapter I to the very low level of milk consumption in India, and to the urgent need for increasing the consumption of this valuable food. In this connexion I outlined the results of experiments which had been made to determine the effect of adding a supplement of milk to the diets of children of school age. Briefly these results showed that children who received the milk supplement increased in weight and height far more rapidly than those who received no supplement, while they also showed a marked improvement in general health.

It is obviously desirable that steps should now be taken to put into effect a more general scheme for the provision of milk to children of school age. The original experiment was carried out by the Municipality of Simla, but already a number of other municipalities have given consideration to the adoption of similar schemes. The difficulty is, however, to raise sufficient funds to meet the very considerable expenditure involved. As is stated in the report of the Simla experiment, " the urgent need for the expansion of the scheme is clear ; the means to do so are not so obvious "(1).

In the original Simla experiment, one pound of whole milk was given daily to each of 120 children. The milk for the experiment was purchased at 2 annas per lb. For a full school year of 200 days this would involve an expenditure of Rs. 25 per child. It is very doubtful whether any municipality could afford to allocate such a large *per capita* sum for the provision of milk to school children. Two alternatives appear to be open, namely, to reduce the cost of the schemes or to secure additional financial assistance from outside the municipalities. In practice I think that both these measures would need to be adopted.

As regards reduction of cost, the first step would be to limit the scope of the scheme to certain selected groups of children. It would probably be desirable to confine the scheme to children attending primary schools and within these schools to select only such children as are underweight, neglected or indigent. This would probably include 30 per cent. of the primary school population(2). The second step would be to effect a reduction in the cost of the milk. The milk used in the Simla experiment was pasteurised and bottled. This is an ideal method of supply for schools, but is far too expensive to be practicable on a large scale. The alternative, namely, to purchase ' loose ' milk, is open to some objection on hygienic grounds, but appears inevitable. In any event it seems preferable to adopt this alternative than to abandon all attempts to initiate a scheme. ' Loose ' milk can be purchased at Rs. 4 per maund(3). This would reduce the cost per child per year from Rs. 25 to Rs. 10. A still further reduction could be effected by using separated milk in place of whole milk. It appears from experiments carried out at the Nutrition Institute, Coonoor, that separated milk is as valuable a supplement for the feeding of school children as whole milk(4). Liquid skimmed milk can be obtained in cities at Rs. 1½ per maund(3), which would involve a cost of Rs. 3¾ per child

(1) W. H. Crichton. Second Report of the Milk Scheme sanctioned by the Simla Municipality.

(2) Personal communication from the Medical Officer of Health, Simla.

(3) This figure refers to milk purchased in Delhi. Whole milk could probably be bought in villages at very much lower prices, say 6 pies per lb. or Rs. 2½ per maund. All such loose milk would need to be boiled before being consumed by the children.

(4) W. R. Aykroyd and B. G. Krishnan. " The Effect of Skimmed Milk, Soya Bean and other Foods in supplementing typical Indian Diets." *Ind. Journ. Med. Res.* 24. 4 (1937).

per year An alternative source would be to use reconstituted skimmed milk powder This can be purchased at Rs 36 per cwt, the annual *per capita* cost on this basis being Rs 5 These figures are, however, calculated on a supplement of 1 lb of milk per school day The English milk in schools scheme only allows for one-third of a pint per day, *i e*, just under half a pound While a full pound would be desirable under Indian conditions half this quantity of milk would be preferable to none at all

Turning to the provision of financial assistance from outside sources there are, I think, three possibilities In the first place the system might be adopted of providing the milk cheap but not free except in cases of obvious under nutrition This is the basis of the English milk in schools scheme, and although it might not be workable under Indian conditions, its possible application should at least be explored In the second place provincial governments might be invited to assist in initiating the scheme by making suitable grants in aid to municipalities and district boards The direct expenditure incurred by the latter would thus be substantially reduced In the third place, efforts might be made to obtain voluntary subscriptions from the wealthier sections of the population, a method which has I understand, met with considerable success in Delhi In this connexion too, I suggest that the interest of the supporters of *goushalas* and *pinjrapoles* might be enlisted, with the object of obtaining cheap or even free milk for school children from such institutions I am convinced that the inclusion of such philanthropic work among the beneficent objects of *goushalas* and *pinjrapoles* would add to the interest and support given to them by all classes of the community

The above suggestions are intended to be illustrative rather than exhaustive, but they serve to show that with suitable organisation some form of school milk scheme should be feasible The subject is obviously one of great difficulty In British India alone there are over ten million scholars in primary schools, and the provision of a daily supply of milk for even a fraction of these would inevitably involve very considerable expenditure The whole question is however of such potential importance to the future health of the population that I believe it merits most careful and serious consideration

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It is obviously desirable that steps should now be taken to put into effect a more general scheme for the provision of milk to children of school age. The original experiment was carried out by the Municipality of Simla, but already a number of other municipalities have given consideration to the adoption of similar schemes. The difficulty is, however, to raise sufficient funds to meet the very considerable expenditure involved. As is stated in the report of the Simla experiment, " the urgent need for the expansion of the scheme is clear ; the means to do so are not so obvious "(1).

In the original Simla experiment, one pound of whole milk was given daily to each of 120 children. The milk for the experiment was purchased at 2 annas per lb. For a full school year of 200 days this would involve an expenditure of Rs. 25 per child. It is very doubtful whether any municipality could afford to allocate such a large *per capita* sum for the provision of milk to school children. Two alternatives appear to be open, namely, to reduce the cost of the schemes or to secure additional financial assistance from outside the municipalities. In practice I think that both these measures would need to be adopted.

As regards reduction of cost, the first step would be to limit the scope of the scheme to certain selected groups of children. It would probably be desirable to confine the scheme to children attending primary schools, and within these schools to select only such children as are underweight, neglected or indigent. This would probably include 30 per cent. of the primary school population(2). The second step would be to effect a reduction in the cost of the milk. The milk used in the Simla experiment was pasteurised and bottled. This is an ideal method of supply for schools, but is far too expensive to be practicable on a large scale. The alternative, namely, to purchase ' loose ' milk, is open to some objection on hygienic grounds, but appears inevitable. In any event it seems preferable to adopt this alternative than to abandon all attempts to initiate a scheme. ' Loose ' milk can be purchased at Rs. 4 per maund(3). This would reduce the cost per child per year from Rs. 25 to Rs. 10. A still further reduction could be effected by using separated milk in place of whole milk. It appears from experiments carried out at the Nutrition Institute, Coonoor, that separated milk is as valuable a supplement for the feeding of school children as whole milk(4). Liquid skimmed milk can be obtained in cities at Rs. 1½ per maund(3), which would involve a cost of Rs. 3¾ per child

(1) W. H. Crichton. Second Report of the Milk Scheme sanctioned by the Simla Municipality.

(2) Personal communication from the Medical Officer of Health, Simla.

(3) This figure refers to milk purchased in Delhi. Whole milk could probably be bought in villages at very much lower prices, say 6 pies per lb. or Rs. 2½ per maund. All such loose milk would need to be boiled before being consumed by the children.

(4) W. R. Aykroyd and B. G. Krishnan. " The Effect of Skimmed Milk, Soya Bean and other Foods in supplementing typical Indian Diets." *Ind. Journ. Med. Res.* 24, 4 (1937).

per year An alternative source would be to use reconstituted skimmed milk powder This can be purchased at Rs 36 per cwt, the annual *per capita* cost on this basis being Rs 5 These figures are, however, calculated on a supplement of 1 lb of milk per school day The English milk in schools scheme only allows for one-third of a pint per day, *i e*, just under half a pound While a full pound would be desirable under Indian conditions, half this quantity of milk would be preferable to none at all

Turning to the provision of financial assistance from outside sources there are, I think, three possibilities In the first place the system might be adopted of providing the milk cheap but not free, except in cases of obvious under nutrition This is the basis of the English milk in schools scheme, and although it might not be workable under Indian conditions, its possible application should at least be explored In the second place provincial governments might be invited to assist in initiating the scheme by making suitable grants in aid to municipalities and district boards The direct expenditure incurred by the latter would thus be substantially reduced In the third place, efforts might be made to obtain voluntary subscriptions from the wealthier sections of the population, a method which has I understand, met with considerable success in Delhi In this connexion, too, I suggest that the interest of the supporters of *gowshalas* and *pinjrapoles* might be enlisted, with the object of obtaining cheap or even free milk for school children from such institutions I am convinced that the inclusion of such philanthropic work among the beneficent objects of *gowshalas* and *pinjrapoles* would add to the interest and support given to them by all classes of the community

The above suggestions are intended to be illustrative rather than exhaustive, but they serve to show that with suitable organisation some form of school milk scheme should be feasible The subject is obviously one of great difficulty In British India alone there are over ten million scholars in primary schools, and the provision of a daily supply of milk for even a fraction of these would inevitably involve very considerable expenditure The whole question is however of such potential importance to the future health of the population that I believe it merits most careful and serious consideration

APPENDIX V.—The Importance of Goats as Milch Animals.

So far as India's total output of milk is concerned, the goat contributes only a very small proportion, a recent survey showing the following figures(1) :—

	Quantity of Milk (thousands of maunds).	Percentage of total.
Cows	378,730	54·7
Buffaloes	300,090	43·6
Goats	10,785	1·6
Others	324	0·1
	689,929	100·0

Moreover from marketing reports it appears that goats are generally kept not so much for the production of milk as for meat and incidentally for hides and skins. The number of goats in India is, however, very large. There are more than 38 million in British India, and nearly 16 million in Indian States. An increase in the *per capita* milk yield of goats would therefore markedly increase the quantity of milk available in the country.

According to recent surveys, the average lactation yields of goats vary from 45 lbs. to 276 lbs., the mean value being 160 lbs. The daily milk yield varies from 2 ozs. in Bihar and Orissa to 12 ozs. in south-western Punjab and Sind, the average for India being about 7 ozs. The lactation periods vary from 120 to 150 days. These figures refer to goats kept under village conditions. Under such conditions they are seldom stall-fed, and they may have to roam for many miles in search of food. The low milk yields of village goats are therefore not surprising. Under more favourable conditions goats may give very much higher yields, and may kid more frequently. Thus the milk yields of goats at the Mission Farm at Etah, U. P., have been increased by better management and selection from 1.1 lb. per day to 2.3 lbs. per day for the Jumna Pari breed, from 1.5 lbs. to 2.0 lbs. per day for the Bar-bari breed, and from 1.1 lbs. to 2.6 lbs. for the local village type(2). At the same time the kidding interval has been reduced from an average of 360 days to an average of about 260 days. Both at Etah and at the Government Cattle Breeding Farm, Hissar, Punjab(3), remarkably high yields have been obtained with some animals, yields of 600 to 1,200 lbs. being not unfrequently recorded, with one exceptional figure of 1,713 lbs. The maximum daily yields of such goats varied from 3½ to 7 lbs., and the average daily yields from 1¼ to 4½ lbs.

These figures show the potentialities of Indian breeds of goats as milking animals. As with village cattle, there is no doubt that better feeding and management alone would markedly increase the milk yields of country goats. Work such as that proceeding at Etah and at Hissar is, however, of great importance in demonstrating the value of selective breeding, combined with better feeding and management, in improving the milking capacities of indigenous stock.

(1) Provisional figures from Provincial Marketing Surveys.

(2) Annual Reports of Mr. A. E. Slater's Goat Breeding Scheme. Imperial Council of Agricultural Research, Simla. 1932-1936.

(3) Punjab figures obtained from brief.

APPENDIX VI—A Note on the Need for the Co-ordination of Rural Services

During my tour I was concerned to find a very general lack of co-ordination between the work of the different government departments in the field of rural development. This applies not only to the isolation of departmental activities. It was equally apparent in the lack of co-ordinated and long range schemes of development and in the piece-meal methods adopted in establishing new enterprises. This cannot be better illustrated than in the words of a prominent member of the Indian Forestry Service :—"The revenue department is anxious to collect its revenue, the forest department to grow trees, the agricultural department to cultivate better paying crops, the veterinary department to rear more stock, the local land owner to keep a stud bull, the irrigation department to find more canal water, the public health authorities to improve the drinking water. These are all competing for the areas which should be the natural fodder reserves of the province ......"(1) This statement, which refers to the foothills of the northern provinces, applies with equal force in other areas. There appears to be no means of bringing together those responsible for the various branches of rural development and ensuring that their interests are complementary rather than competitive.

The need for such co-ordination in rural development is particularly apparent in relation to cattle breeding and dairying. Cattle breeding necessitates the closest co-operation between the veterinary, agricultural and forestry departments(2). Dairying involves in addition a number of *problems* connected with marketing and co-operation, as well as certain public health considerations. No authority at present exists through which these various interests can be co-ordinated. It may be argued that all such activities are under the control of a single minister. This is not true for all provinces. Moreover the responsible minister can seldom give to the questions at issue that detailed consideration which is essential in harmonising conflicting interests.

After considering various alternatives I feel that the difficulty could best be met in most provinces by constituting a Board of Rural Development(3), which would include the directors of the departments of agriculture, forestry, veterinary services and public health, a representative of the irrigation and of the revenue departments and the Registrar of Co-operative Societies. Specialist officers, namely, the provincial live-stock expert, the provincial marketing officer, the provincial dairy development officer and the fodder specialist (if appointed) should attend meetings of the Board in an advisory capacity. The Chairman of the Board would hold a key position and *the success of the Board's work could* depend largely on his tact and personality. I consider it essential that he should be a non technical officer of the rank of Commissioner and with

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(1) R. M. Gorrie. "Notes on the Conservation of Hill Grazings." Paper presented at the Second Animal Husbandry Wing Meeting, Madras, 1936.

(2) The irrigation department *ought also to be* included. On several occasions I was informed that irrigation developments had adversely affected the cattle in what had previously been excellent breeding tracts.

(3) A proposal to constitute such a Board was considered by the Government of Bombay in 1934. This proposal included however the unification of the departments of agriculture, veterinary services and co-operation into a combined department with *the director of agriculture as head*. The scheme therefore differed fundamentally from that now put forward since it included the appointment of a technical officer as head and the loss of administrative independence by the departments of veterinary services and co-operation. Under these circumstances it is not surprising that the proposal was [illegible]

special knowledge of and interest in rural conditions. Whether the post of Chairman should be a whole-time or a part-time one would depend on individual circumstances. Such a Board should, I believe, act solely as a co-ordinating and advisory body, and should not curb the initiative nor limit the responsibilities of the directors of individual departments, nor interfere with the internal administration of such departments. On the other hand the Board might, on occasion, have to recommend the abandonment of projects which, though good in themselves, failed to fit in with the general scheme of rural development. It should, therefore, be in a position to make direct representations to the responsible ministers in regard to any controversial questions relating to rural development and the co-ordination of rural services. The Board could appoint committees to deal with specific problems or with the development of such activities as marketing or dairying. One of the first duties of such a Board would, I suggest, be to carry out a survey of the agricultural resources of the province in order that any subsequent schemes could be properly related to a long-range policy of rural development.

I am strongly of opinion that the constitution of such a Board would do much towards ensuring inter-departmental co-operation and the direction of departmental work along the most productive lines.(4).

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(4) Since this Appendix was drafted the following resolution, which was adopted at the Cattle Conference held at Simla on 25th and 26th May 1937, has been brought to my Notice :—"The Conference is convinced of the need in every province for a Live-Stock Division with a separate allotment of funds for live-stock improvement work and controlled by a live-stock expert whose whole time is devoted to that subject. *It is probable that the ultimate solution in each province will be found in the eventual establishment of a unified department under one Minister embracing plant industry, animal industry, the control and prevention of animal diseases, the marketing of crop and animal products and rural co-operation, with technical heads for the appropriate divisions.*" If the term "department" is used in the restricted sense which at present applies to the provincial departments of agriculture, and if the proposal entails the control of the various branches of rural work (e.g., plant husbandry, animal husbandry, veterinary services, and co-operation) by a single director of agriculture, whether technical or non-technical, I consider that it would fail to achieve its object. The tendency in recent years has been towards the separation of these branches of work under individual directors who possess specialised knowledge and experience of the various technical problems involved, and I fail to see what new factors have arisen which justify a reversal of this policy. If, on the other hand, the term "department" is intended to imply the creation of a single administrative unit which would be the sole concern of one Minister, but which would not involve the loss of individuality of the various branches of rural work, the proposal could readily be brought into line with my own scheme by the appointment of the responsible Minister as *ex-officio* Chairman of the Board of Rural Development. Under these conditions, however, I feel strongly that, in order to ensure continuity in schemes of rural development, the appointment of a permanent Vice-Chairman of the rank of Commissioner would be essential.

APPENDIX VIII.—ITINERARY.*

November, 1936—

4th	Landed at Bombay.
6th	Arrived at Delhi.
7th to 11th ..	*Delhi*.—Interviews with H. E. the Viceroy, the Hon'ble Member for Education, Health and Lands, the Secretary of the Department of Education, Health and Lands, the Public Health Commissioner to the Government of India, the Director of Supplies and Transport, Army Headquarters, the Officiating Vice-Chairman and the Animal Husbandry Expert of the Imperial Council of Agricultural Research, the Agricultural Marketing Adviser to the Government of India, and other officials. Visits to the Imperial Agricultural Research Institute, Edward Keventer's Dairy Farm, the Delhi Cattle Breeding Farm, and the Delhi *Pinjrapole*.
12th	*Karnal*.—Visits to the Nagloi, Bahadurgarh, Rohtak, Sonepat, Sisana and Panipat Veterinary Hospitals and the Imperial Cattle Breeding Farm, Karnal.
13th and 14th ..	*Hissar*.—Visits to the Government Cattle Breeding Farm.
15th, 16th and 19th	*Lahore*.—Interviews with H. E. the Governor of the Punjab, the Officiating Director of Agriculture and the Director of Veterinary Services. Visits to Keventer's Sales Depot, the Military Dairy Farm, the Public Analyst's Laboratory, the University Chemistry Laboratories, the Punjab Veterinary College, the Lahore *Gowshala*, and to *gujar's* premises and milk shops.
17th	*Ferozepore*.—Visits to the Military Dairy Farm and to the Kahna-Kachha and Lulani Veterinary Hospitals.
18th	*Lyallpur*.—Visits to the Vegetable Ghee Factory and the Agricultural College and Dairy.
20th and 21st ..	*Khanewal*.—Visits to Grantee Farms in the Montgomery area.
22nd and 23rd ..	*Karachi*.—Interviews with H. E. the Governor of Sind, the Officiating Director of Agriculture, the Director of Veterinary Services, and the Director of the Public Health Department. Visits to the Military Dairy Farm, the English Dairy, the Karchi *Pinjrapole* and cattle stables and dairies.
25th and 26th ..	*Ahmedabad*.—Visits to Lord's Dairy, the Dudhia Dairy, the Changodar herd, and local cattle stables and milk shops.
27th	*Chharodi*.—Visit to Government Cattle Breeding Farm.
28th	*Anand*.—Visits to Polson's Dairy and separating stations, and to the Government Creamery.
29th	*Baroda*.—Interviews with H. H. the Gaekwar of Baroda and with the Commissioner for Agriculture. Visits to the Palace Dairy, the Australian Dairy Co., the Niyampura Producer's Co-operative Society, and the Alembic Chemical Works.

*Visits to local villages are not detailed, but frequent opportunities were taken to inspect village conditions in various parts of the country.

30th November to 4th December, 1936	*Bombay*—Interviews with H. E. the Governor of Bombay, the Secretary to Government, Revenue Department, the Municipal Commissioner, the Public Health Officer and others Visits to the Byculla Dairy, the Parisian Dairy, the Infants and Public Milk Supply Company, the Municipal Cold Stores, the Municipal Public Laboratories, the Bombay *Pinjrapole*, the Borivli, Kandivli and Mulund *Gowshalas*, the Bandra slaughter house, the Bombay Veterinary College, the Haffkine Institute, and typical buffalo stables and milk shops
5th and 6th ..	*Poona*—Interviews with the Director of Agriculture, the Director of Veterinary Services, and the Provincial Live-Stock Expert Visits to the Agricultural College and Dairy, the Government House Dairy, and the Military Dairy Farm
7th to 12th ..	*Bangalore*—Interviews with the Dewan of Mysore, the Director of Agriculture, the Director of Veterinary Services and the Live Stock Expert Visits to the Imperial Dairy Institute, Hosur Cattle Breeding Farm, the Hebbal Agricultural and Live Stock Farm, the Indian Institute of Science, the Civil Veterinary Hospital, the Military Dairy Farm, the Lakeview Dairy, the City Milk Supply Co, and local cattle stables and milk shops
13th to 17th ..	*Madras*—Interviews with H E the Governor of Madras, the Director of Agriculture, and the Officiating Director of Veterinary Services Visits to Madras University, Madras Veterinary College, the Garrison Dairy Farm, the Madras Co operative Milk Supply Union, the local *gowshala*, and cattle stables and milk shops Attended the Second Animal Husbandry Wing Meeting
18th	*Katpadi*—Visit to the Mission Goat Breeding Farm
19th and 20th ..	*Coimbatore*—Visits to the Agricultural College and Dairy and to the Pattagar of Palayankottai's Farm
21st to 27th ..	*Coonoor*—Visits to the Nutrition Laboratory at the Pasteur Institute and to Wellington Dairy Farm
28th and 29th ..	*Mysore*—Interview with the President of the Municipal Committee Visits to the Rayankere Dairy Herd, the Chatanhalli Cattle Breeding Farm and the Yellachihalli Sheep Breeding Farm
30th December to 2nd January, 1937.	*Bangalore*—Interviews with the Imperial Dairy Expert Visits to the Irwin Canal Farm, the Mandya Sugar Factory, the Deridan Farm, and the Laboratory of the Agricultural Department
3rd to 6th ..	*Hyderabad*—Interviews with the Chief Minister of H E H the Nizam's Dominions, and with the Director of Agriculture and the Director of Veterinary Services Visits to the Himayatsagar Dairy and Poultry Farm, the Secunderabad Military Dairy Farm, the Veterinary Hospital, the Deccan Dairy, and typical gowal premises Attended the Indian Science Congress
7th and 8th ..	*Nagpur*—Interviews with H E the Governor of the Central Provinces, the Director of Agriculture and the Director of Veterinary Services Visits to the Agricultural College and Dairy, the Telankheri Farm and Co-operative Dairy, the Veterinary Hospital and typical gowal premises

January, 1937—*contd.*

10th to 13th and 16th to 19th.	*Calcutta.*—Interviews with H. E. the Governor of Bengal, the Director of Veterinary Services and the Public Health Officer. Visits to the Bengal Veterinary College, the Municipal Laboratories, the Co-operative Milk Union, Keventer's Dairy, the Express Dairy, the Milk Market and Hogg Market, the Sodepur *Gowshala*, and cattle stables and milk shops.
14th and 15th ..	*Dacca.*—Interviews with the Officiating Director of Agriculture and the Provincial Live-Stock Expert. Visits to the Agricultural Farm and Dairy, to Dacca University, and to local milk shops.
20th and 21st ..	*Darjeeling.*—Visits to the Co-operative Milk Union's premises Keventer's Dairy Farm and typical hill areas.
23rd to 24th February	*Delhi.*—Meetings of the Advisory Board of the Imperial Council of Agricultural Research. Collection of statistical data and discussions with officials of the Council and others.
25th	*Aligarh.*—Visit to Keventer's Dairy Farm.
26th to 28th ..	*Agra.*—Visits to the Military *Ghee* Heating Centre and *Ghee* Testing Laboratory, the Dayalbagh Dairy, the Agricultural Farm at Bichpuri, Singhal's Dairy, and a typical *mandi* at Kasta Fatehabad.
1st March, 1937 ..	*Etah.*—Visit to the Mission Goat Breeding Farm.
2nd	*Muttra.*—Visit to the Government Cattle Breeding Farm.
4th	*Allahabad.*—Visit to the Farm and Dairy of Allahabad Agricultural Institute, the Katra Co-operative Dairy, Mahabir's Dairy, the *khoa* market, the Indalpul and Geneshgunj milking stations, and local *gowshalas'* premises.
5th to 7th ..	*Lucknow.*—Interviews with H. E. the Governor of the United Provinces, the Director of Agriculture, the Deputy Director in charge of Live-Stock Improvement, and the Director of Veterinary Services. Visits to the Parbatpur Co-operative developments, the Makdumpur grazing areas, the Government Cattle Breeding Farm at Kheri, the Military Dairy Farm, and the Diamond Dairy.
8th and 9th ..	*Cawnpore.*—Visits to the Agricultural College and Dairy, the Military Dairy Farm, the Cawnpore *Gowshala*, the *Ghee* Testing Laboratory of the Cawnpore Pure *Ghee* Association, and Messrs. Spencer's Dry Ice Factory.
12th	*Meerut.*—Visit to the Military Grass Farm.
14th to 16th ..	*Simla.*—Visits to Keventer's Dairy Farm, the Simla Veterinary Hospital, and typical hill areas.
17th	*Kasauli.*—Visits to the Military Food Laboratory and the Pasteur Institute.
18th to 23rd ..	*Delhi.*—Interviews with H. E. the Viceroy, the Hon'ble Member for Education, Health and Lands, the Quartermaster General, Army Headquarters, the Joint Secretary of the Department of Education, Health and Lands, the Education Commissioner to the Government of India, the Vice-Chairman and other officials of the Imperial Council of Agricultural Research, the Public Health Officer of New Delhi, and others.
23rd	Left Delhi.
25th	Sailed from Bombay.

January, 1937—*contd.*

10th to 13th and 16th to 19th.	*Calcutta.*—Interviews with H. E. the Governor of Bengal, the Director of Veterinary Services and the Public Health Officer. Visits to the Bengal Veterinary College, the Municipal Laboratories, the Co-operative Milk Union, Keventer's Dairy, the Express Dairy, the Milk Market and Hogg Market, the Sodepur *Gowshala*, and cattle stables and milk shops.
14th and 15th ..	*Dacca.*—Interviews with the Officiating Director of Agriculture and the Provincial Live-Stock Expert. Visits to the Agricultural Farm and Dairy, to Dacca University, and to local milk shops.
20th and 21st ..	*Darjeeling.*—Visits to the Co-operative Milk Union's premises Keventer's Dairy Farm and typical hill areas.
23rd to 24th February	*Delhi.*—Meetings of the Advisory Board of the Imperial Council of Agricultural Research. Collection of statistical data and discussions with officials of the Council and others.
25th	*Aligarh.*—Visit to Keventer's Dairy Farm.
26th to 28th ..	*Agra.*—Visits to the Military *Ghee* Heating Centre and *Ghee* Testing Laboratory, the Dayalbagh Dairy, the Agricultural Farm at Bichpuri, Singhal's Dairy, and a typical *mandi* at Kasta Fatehabad.
1st March, 1937 ..	*Etah.*—Visit to the Mission Goat Breeding Farm.
2nd	*Muttra.*—Visit to the Government Cattle Breeding Farm.
4th	*Allahabad.*—Visit to the Farm and Dairy of Allahabad Agricultural Institute, the Katra Co-operative Dairy, Mahabir's Dairy, the *khoa* market, the Indalpul and Geneshgunj milking stations, and local *gowshalas'* premises.
5th to 7th ..	*Lucknow.*—Interviews with H. E. the Governor of the United Provinces, the Director of Agriculture, the Deputy Director in charge of Live-Stock Improvement, and the Director of Veterinary Services. Visits to the Parbatpur Co-operative developments, the Makdumpur grazing areas, the Government Cattle Breeding Farm at Kheri, the Military Dairy Farm, and the Diamond Dairy.
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18th to 23rd ..	*Delhi.*—Interviews with H. E. the Viceroy, the Hon'ble Member for Education, Health and Lands, the Quartermaster General, Army Headquarters, the Joint Secretary of the Department of Education, Health and Lands, the Education Commissioner to the Government of India, the Vice-Chairman and other officials of the Imperial Council of Agricultural Research, the Public Health Officer of New Delhi, and others.
23rd	Left Delhi.
25th	Sailed from Bombay.

TABLE 1.—*Estimated total production of milk, and estimated production and consumption per head of twenty countries* (*).

Country.	Total production of milk 1930-34.	Human population.	Daily production per head of population.	Daily consumption† per head of population
	(Million gallons.)	(Thousands.)	(Oz.)	(Oz.)
New Zealand ..	870	1,559	244	56
Denmark ..	1,200	3,551	148	40
Finland ..	620	3,666	74	63
Sweden	980	6,233	69	61
Australia	1,049	6,630	69	45
Canada	1,580	10,377	66	35
Switzerland ..	607	4,066	65	49
Netherlands ..	970	7,935	54	35
Norway	290	2,814	45	43
U. S. A.	10,380	122,775	37	35
Czechoslovakia ..	1,200	14,730	36	36
Belgium	651	8,092	35	35
Austria .. .	545	6,760	35	30
Germany . ..	5,096	66,030	34	35
France	3,150	41,835	33	30
Poland . ..	1,990	31,948	27	22
Great Britain .	1,474	45,266	14	39
Italy	1,050	41,177	11	10
Roumania .	382	19,033	9	9
India	6,400‡	352,838	8	7

* The first and fourth columns are taken from the Problem of Nutrition Volume IV. Statistics of Food Production, Consumption and Prices (League of Nations Publication) The second column is from latest Census figures The third column is calculated from the figures in the first and second columns.

† Includes both liquid milk and milk products, expressed in milk equivalents.

‡ Assuming India's total production to be 800 million maunds.

TABLE 2.—*Milk production and consumption by provinces.*

Province.	Daily Production per head (a). oz.	Daily Consumption per head (b). oz.
Assam	1·4	2·2
Bengal	3·1	1·9
Madras	3·6	1·6
Bombay	4·7	4·0
United Provinces	4·7	5·0
Central Provinces	6·1	0·8
Bihar and Orissa	6·4	3·2
Punjab	18·3	9·9

(*a*) Provincial Marketing Surveys.
(*b*) Sir John Megaw's figures.

TABLE 3.—*Milk consumption in certain municipalities.*

Province.	Municipality.	Consumption per head per day (oz.).		
		Milk.	*Ghee.*	Other milk products.
Bengal	Kharagpur ..	3·1	0·24	0·29
Madras	Madras	1·4	0·18	0·10
Bombay	Surat	6·1	0·75	0·35
United Provinces ..	Lucknow ..	1·4	0·35	0·27
	Agra	2·6	0·42	0·67
Central Provinces ..	Jubbulpore ..	0·9	0·28	0·01
Bihar	Bhagalpur ..	0·5	0·08	0·19
Punjab	Lahore	2·0	0·40	0·01
	Amritsar ..	7·3	1·25	2·61

TABLE 4 —*Effect of a supplement of whole milk on the growth of school children*

Groups	On Milk				Control			
	Average gain in three months				Average gain in three months			
	Boys		Girls		Boys.		Girls	
	Weight	Height	Weight	Height	Weight	Height	Weight	Height
	Lb	In	Lb	In	Lb	In	Lb	In
Group I	3 92	0 80	5 35	0 78	1 60	0 60	1 1	0 18
Group II	3 90	0 70	4 33	0 38	1 56	0 46	1 1	Nil
Group III	3 70	0 53	3 00	0 19	1 90	0 42	1 0	0 07
Group IV			5 50	0 29			0 5	Nil
Average	3 84	0 67	4 54	0 41	1 6	0 49	0 92	0 06

TABLE 5 —*Effect of a supplement of skimmed milk on the growth of school childern*

—		Average increase in weight in three months	Average increase in heigt in three months
		Lb	In
Hostel 1 (Boys)	Group A (receiving milk)	4 77	0 61
	Group B (not receiving milk)	2 13	0 35
	Group B (receiving milk)	3 07	0 69
	Group A (not receiving milk)	1 10	0 43
Hostel 2 (Girls)	Girls receiving milk	4 8	0 80
	Girls not receiving milk	0 8	53
Hostel 3 (Boys)	Boys receiving milk	4 57	0 62
	Same boys receiving no milk	0 84	(?)

TABLE 6.—*Amount spent on food and proportion spent on milk products (per family per month).*

Inquiry.	Bombay (1922).	Bombay (1932).	Sholapur (1925).	Ahmedabad (1924).
	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
Total expenditure on food	27 2 11	21 6 10	18 10 5	22 12 7
Expenditure on milk	0 13 9	1 3 9	0 15 7	0 13 10
Expenditure on *ghee*	0 9 11	0 5 0	0 5 1	2 8 3
Total expenditure on milk products ..	1 7 8	1 8 9	1 4 8	3 6 1
Percentage of food expenditure spent on milk products	5·4%	7·2%	6·9%	14·8%
Number of families	2,473	1,469	1,055	872
Average size of family	4·8	4·4	4·7	3·9

TABLE 7.—*Influence of income level on milk consumption (Bombay 1922*).*

Income Groups (Rs. per mensem).	Consumption of		Expenditure on		Percentage† expenditure on milk and *ghee*.
	Milk.	*Ghee.*	Milk.	*Ghee.*	
	(Lb.)	(Lb.)	Rs. a. p.	Rs. a. p.	
Below 30	1·0	0·3	0 3 1	0 4 6	3·0
30 to 40	2·0	0·2	0 6 7	0 3 10	3·2
40 to 50	2·2	0·3	0 7 10	0 5 10	3·7
50 to 60	4·0	0·5	0 14 6	0 9 8	5·3
60 to 70	5·2	0·6	1 2 9	0 12 7	6·3
70 to 80	7·3	1·1	1 9 10	1 5 9	8·1
80 to 90	7·9	1·5	2 1 4	1 10 7	9·1
90 and above	13·6	2·0	3 2 0	2 7 3	11·2
All incomes	3·9	0·5	0 13 9	0 9 11	5·4

*All values given per family per month.

†These figures refer to the proportion of total food expenditure spent on milk and *ghee.*

TABLE 8.—*Influence of income level on milk consumption (Lahore 1930).*

Income groups. (Rs. per mensem).	Daily consumption per head. (Oz.)
Up to 25	2·8
26 to 50	9·2
51 to 100	12·0
101 to 200	13·6
201 to 500	16·0
501 to 1,000	20·0
1,001 to 1,500	31·2
1,501 to 2,000	31·2
2,001 and more	31·2
Average for Lahore	4·0

TABLE 9.—*Utilisation of milk in India.*

	Million Maunds.	As percentage of total milk production.	As percentage of total milk manufactured.
Total production of milk	690*		
Utilised—			
(a) as liquid milk	215·0	31·2	
(b) for manufacture	475·0	68·8	
Manufactured products ·			
Ghee	364·0	52·7	76·5
Khoa	52·2	7·6	11·0
Other indigenous milk products†	16·7	2·4	3·5
Dahi (curds)	26·2	3·8	5·6
Butter‡	10·3	1·5	2·2
Cream	2·8	0·4	0·6
Ice-cream	2·8	0·4	0·6
Cheese	(negligi-	..	..

[illegible]

TABLE 10.—*Total value of milk and milk products produced in India.*

Product.	Maunds of milk equivalent (millions).	Retail value per maund of milk.	Value (crores of rupees).
		Rs.	
Liquid milk	215·0	5	107·5
Ghee	364·0	2¾	100·0
Khoa	52·2	7½	39·2
Other indigenous milk products ..	16·7	13	22·3
Dahi (curd)	26·2	7½	19·7
Butter	10·3	3	3·0
Cream	2·8	3	1·7
Ice-cream	2·8	3	
	690·0	..	293·4

NOTE.—Liquid milk has been valued at 1 anna per lb., the cost of production working out at 9-10 pies per lb. This may be too high a value to place on the milk. On the other hand the *ghee* has been valued at its retail price, no allowance being made for the value of the butter-milk (*lassi*) consumed by the cultivator and his family.

TABLE 11.—*The urban and rural populations of India.*

——	Number of towns or villages.	Population (in millions).	Percentage of population.
Total Population	..	*352·8*	*100*
Urban Areas	..	*39·0*	*11·0*
Towns having :—			
100,000 and over	38	9·7	2·7
50,000 to 100,000	65	4·6	1·3
20,000 to 50,000	268	8·1	2·3
10,000 to 20,000	543	7·4	2·1
5,000 to 10,000	987	7·0	2·0
Under 5.000	674	2·2	0·6
Rural Areas	..	*313·8*	*89·0*
Villages having :—			
5,000 and over	1,343	5·3	1·5
2,000 to 5,000	18,162	38·7	11·0
500 to 2,000	167,449	139·0	39·4
Under 500	509,786	130·8	37·1

TABLE 12 —*Adulteration of milk in different provinces during 1933-1935.*

	1933			1934			1935		
	No of samples examined	No of samples adulterated	Percentage of samples found adul terated	No of samples examined	No of samples adulterated	Percentage of samples found adul terated	No of samples examined	No of samples adulterated	Percentage of samples found adul terated
Bombay	5 646	1 477	26 2	6,289	1 420	22 6	6,583	1,800	27 3
Bengal	4 387	1,662	37 9	5 088	1,850	36 4	5,278	1 866	35 3
Madras	1 078	647	60 0	1,458	933	64 0	1,798	1,182	65 7
Assam	274	98	35 8	369	175	47 4	359	156	43 4
United Provinces	1 428	381	26 7	1,581	418	26 4	1,901	410	21 6
Punjab	2,377	452	19 0	1 531	342	22 3	1,016	332	32 7
Bihar	204	106	52 0	226	139	61 5	269	146	54 2
Sind	681	295	43 3	526	206	39 1	447	224	50 1
North West Frontier Province	60	31	51 7	23	10	43 5	28	18	64 4
Total	16,135	5,149	31 9	17,091	5 493	32 1	17,679	6,134	34 7

TABLE 13.—*Percentage of added water in typical samples of milk.*

Percentage of water added.	Number of samples.
0	22
6 to 15	29
16 to 25	23
26 to 35	16
36 to 45	7
46 to 55	3
Total ..	100

TABLE 14.—*Acidities of samples of* ghee.

Reading point.	Number of samples examined.	Percentage of total examined.
2·0—2·9	2	..
3·0—3·9	144	3·1
4·0—4·9	154	3·5
5·0—5·9	243	5·6
6·0—6·9	567	13·0
7·0—7·9	997	22·8
8·0—8·9	1,600	36·6
9·0—9·9	606	13·9
10·0—10·9	65	1·5
11·0—11·9	2	..
Total ..	4,380	100·0

TABLE 15.—*Adulteration of ghee in different provinces during 1933-1935.*

—	1933.			1934.			1935.		
	No. of samples examined.	No. of samples adulterated.	Percentage of samples found adulterated.	No. of samples examined.	No. of samples adulterated.	Percentage of samples found adulterated.	No. of samples examined.	No. of samples adulterated.	Percentage of samples found adulterated.
Bombay	1,522	198	13·0	2,354	155	6·6	1,796	165	9·2
Bengal	3,247	607	18·7	4,013	1,091	27·1	4,634	1,586	34·2
Madras	1,189	402	33·8	1,651	747	45·2	1,548	686	44·3
Assam	78	43	55·1	92	55	59·8	164	85	51·8
United Provinces	3,022	266	8·8	3,746	842	22·5	4,556	904	19·8
Punjab	115	25	21·7	107	47	43·9	206	92	44·7
Bihar	359	168	46·8	506	327	64·7	801	473	59·2
Sind	770	291	37·7	774	356	45·9	1,581	632	39·9
North-West Frontier Province ..	95	56	59·0	104	44	42·3	105	43	41·0
Total ..	10,397	2,056	19·8	13,347	3,664	27·4	15,391	4,066	30·3

... distribution of butyro-refractometer readings and Reichert-Meissl values of ghee.

Range.	Butyro-refractometer readings. Percentage of readings falling within range.		
	Sunawala and Kothavalla.	Godbole and Sadgopal.	Military Food Laboratory.
40·0—40·9 ..	..	6·7	1·4
41·0—41·9 ..	..	24·4	96·0
42·0—42·9 ..	14·6	62·2	2·6
43·0—43·9 ..	65·9	6·7	..
44·0—44·9 ..	14·6	..	..
45·0—45·9 ..	4·9	..	..
	100·0	100·0	100·0

Range.	Reichert-Meissl values. Percentage of readings falling within range.		
	Sunawala and Kothavalla.	Godbole and Sadgopal.	Military Food Laboratory.
Below 23·0 ..	4·9	..	..
23·0—24·9 ..	2·4	3·2	..
25·0—26·9 ..	48·7	16·2	..
27·0—28·9 ..	9·8	19·3	..
29·0—30·9 ..	9·8	32·2	7·1
31·0—32·9 ..	14·6	16·2	66·0
33·0—34·9 ..	9·8	12·9	26·9
	100·0	100·0	100·0

TABLE 17 —*Exports of* ghee *from India and imports of* ghee *into Malaya*

Year	Total exports from India	Value of total exports	Value of exported ghee per maund	Indian imports into Malaya	Percentage of Indian exports going to Malaya	Percentage of Malaya's imports obtained from India
	(Cwt)	(Rs lakhs)	(Rs)	(Cwt)		
1928 29	38 605	37 9	70	27,400	71 0	95 5
1929 30	35 579	35 1	71	24,580	69 1	93 7
1930 31	31,123	28 5	66	20,260	65 0	96 3
1931 32	27,294	22 2	58	13 900	51 0	95 2
1932 33	21,837	15 9	52	12,960	59 3	94 1
1933 34	24 418	13 3	39	13,620	55 8	95 4
1934 35	25,526	14 6	41	13,900	54 5	96 8

TABLE 18.—*Quantities and value of butter imported into India.*

Year.	Quantity.	Value
	(Cwt.)	(Rs.)
1926-27	1,091	2,25,247
1927-28	1,590	2,78,253
1928-29	1,335	2,51,959
1929-30	2,255	4,06,360
1930-31	2,625	4,70,391
1931-32	3,570	5,42,397
1932-33	3,772	5,23,500
1933-34	5,106	5,78,346
1934-35	6,265	6,23,654
1935-36	7,708	..

TABLE 19.—*Returns from various milk products.*

Product.	Out-turn per 100 lb. milk.	Retail price per lb.	Gross return per maund of milk.		Relative return per 100 lb. milk.
	Lb.	As.	Rs.	as.	
Ghee	6	9	2	11	54
'Country' butter ..	7	9	3	2	63
Liquid milk ..	100	1	5	0	100
Dahi	85	1¾	7	7	149
Khoa	25	6	7	8	150
Channa	20	8	8	0	160
Mallai	20	10	10	0	200
Rabree	40	8	16	0	320

TABLE 20 —*Imports of cheese into India.*

Year	Quantity	Year.	Quantity
	(Cwt)		(Cwt)
1926 27 .	11,258	1931 32 . .	7,349
1927 28	11,607	1932 33 ..	8,858
1928-29 .	11,121	1933 34	9,871
1929-30 .	10,876	1934 35 ..	10,924
1930 31 . .	10,443	1935 36	10,546

TABLE 21 —*Imports of milk products.*

Nature of Product.	Approximate quantity imported	Milk equivalent of imports
	(Cwt)	(Maunds)
Unsweetened condensed milk, whole	25,000	70,000
Sweetened condensed milk, whole	25,000	70,000
Sweetened condensed milk, skimmed	150,000	550,000
Dried milk powder, whole	25	200
Dried milk powder, skimmed	250	3,500
Preserved cream	50	350
Sterilised milk	150	150
Total	200,475	694,200

TABLE 22 —*Imports of condensed and dried milks into India*

Year	Quantity	Year	Quantity
	(Cwt)		(Cwt)
1926 27	182,845	1931 32	185,925
1927 28	224,036	1932 33 .	172,332
1928 29	245,153	1933 34 .	171,870
1929 30	242,611	1934 35 .	180,942
1930-31	226,853	1935 36 . ..	209,214

TABLE 23.—*Number of bulls issued annually from Government farms in certain provinces (average figures).*

—	1923-24 to 1925-26.	1929-30 to 1931-32.	1932-33 to 1934-35.	1935-36.
Assam	7	15	36	42
Bengal	5	13	30	33
Bombay	30	17	28	23
Central Provinces	52	41	62	36
Madras	20	74	69	103
Punjab	320	336	551	616
United Provinces	75	145	142	141
Total ..	509	641	918	994

TABLE 24.—*Number of approved bulls at stud in certain provinces (average figures).*

—	1929-30 to 1931-32.	1932-33 to 1934-35.	1935-36.
Assam	32	115	200
Bengal	79	360	487
Bombay	102	227	289
Central Provinces	73	104	132
Madras	104	134	181
Punjab	3,579	4,323	5,035
United Provinces	2,696	3,245	3,448
North-West Frontier Province ..	170	233	234
Total ..	6,835	8,741	10,006

TABLE 25.—*Number of castrations performed in veterinary hospitals and dispensaries and during district work (British India).*

Year.	Castrations performed in hospitals and dispensaries.	Castrations performed in district work.	Total number of castrations performed.
1928-29	206,941	303,958	510,899
1929-30	243,562	353,628	597,190
1930-31	284,968	415,126	700,094
1931-32	337,957	463,297	801,254
1932-33	380,880	512,184	893,064
1933-34	430 675	575,456	996,131
1934 35	497,111	612,034	1,109,145

TABLE 26.—*Bovine castrations performed in British India during 1934-35.*

Province.	Total bovine castrations.	Total male bovine population.	Percentage castrated.	Index number.*
Assam	21,843	3,068,042	0·69	10·8
Bengal	4,120	13,497,435	0·03	0·4
Bombay	35,379	4,868,561	0·72	11·3
Central Provinces ..	156,795	7,073,711	2·21	32·9
Madras	51,812	11,550,103	0·45	7·5
Punjab	441,787	6,914,964	6·38	100·0
United Provinces ..	22,374	15,813,997	0·14	2·1
North-West Frontier Province.	32,834	476,751	6·80	107·8
Bihar and Orissa ..	110,034	11,006,149	0·99	15·5
Sind	2,968	990,102	0·29	4·5

*In this the Punjab percentage, i.e., 6·38 is taken as equal to 100.

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TABLE 27.—*Influence of milk yield on cost of milk production.*

Breed.	Average lactation yield.	Feed cost per lb. of milk.	Labour cost per lb. of milk.	Total cost per lb. of milk.
	(lb.)	(Pies.)	(Pies.)	(Pies.)
Half-bred	6,500	3·55	0·83	6·49
Ferozepore Sahiwal	5,717	3·88	0·94	7·16
Scindi	4,150	4·48	1·51	9·42
Ordinary Sahiwal ..	3,864	4·45	1·29	9·18
Buffaloes	4,000	5·68	1·29	11·14

TABLE 28.—*Average lactation yields of European cross-bred cows.*

Breed.	Average lactation yields. (lb.)						Average number of days in milk					
	1931-32.	1932-33.	1933-34.	1934-35.	1935-36.	Mean.	1931-32.	1932-33.	1933-34.	1934-35.	1935-36.	Mean.
Pure Indian	4,092	3,678	3,065	2,130	3,272	3,247	296	274	251	265	282	273
[illegible] European	4,202	3,874	6,662	5,445	4,514	4,939	308	256	316	301	292	295
[illegible] European	4,837	5,389	4,966	4,954	5,247	5,078	319	310	302	297	321	310
[illegible] European	5,957	6,665	7,129	6,509	10,030	6,252*	313	337	347	307	392	321
[illegible] European	6,409	6,855	7,085	6,908	7,040	6,859	338	315	331	315	322	324
[illegible] European	6,272	6,851	6,494	6,873	7,595	6,817	340	310	310	312	331	321
[illegible] European	6,140	6,885	7,283	7,002	6,580	6,778	329	335	335	327	317	329

* Omitting the exceptional value of 1935-36.

TABLE 29.—*Progressive increase in milk yield shown by herds at Lyallpur, Karnal, Pusa and Ferozepore from the date of their establishment.*

—	Average daily yield. (lbs.)				Overall.*
	Lyallpur Agricultural College Dairy.	Karnal.	Pusa.	Ferozepore.	
First year	5·60	8·8	5·8	11·3	4·6
Second year	5·40	7·1	7·6	11·6	5·9
Third year	6·80	8·4	8·3	12·9	8·6
Fourth year	7·18	8·6	6·6	12·9	9·2
Fifth year	7·45	10·2	6·8	12·6	9·8
Sixth year	8·60	10·0	6·1	14·8	10·6
Seventh year	9·31	9·9	7·4	14·7	11·3
Eight year	7·271†	12·2	8·2	15·0	11·1
Ninth year	9·10	12·9	8·0	16·2	11·9
Tenth year	9·30	13·2	9·4	16·4	11·7
Eleventh year	9·03	13·2	10·8	17·4	12·5
Twelfth year	9·80	14·1	12·0	16·4	12·1
Thirteenth year	11·28	..	12·3	15·3	9·9
Fourteenth year	10·73	..	11·7	18·0	12·5
Fifteenth year	11·07	..	12·7	17·0	12·5
Sixteenth year	11·40	..	14·3	15·4	12·0
Seventeenth year.. ..	11·67	..	12·4	16·9	12·9
Eighteenth year	12·82	..	13·0	17·7	12·8
Nineteenth year	11·43	..	13·6	20·3	17·0
Twentieth year	15·05	..	18·5	22·6	16·8
Twenty-first year ..	16·54	..	..	18·3	13·7
Twenty-second year ..	17·15	..	..	16·5	11·1

NOTE.—Karnal herd (Hariana and Tharparkar) was started in 1923 and Pusa and Ferozepore (Sahiwal) in about 1912, and the Lyallpur herd (Sahiwals) in 1914.

* These are overall averages, *i.e.*, averages computed over milking and dry stock, whereas those shown in other columns are milking averages. Further the progressive increase of the Ferozepore herd is often masked by the influx of fresh cows which are purchased in the market for meeting the requirements of trade. These are not separately shown in administration reports.

† Fall due to severe attack of Foot-and-mouth disease.

TABLE 30.—*Distribution of milk yields in three Sahiwal herds.*

Name of farm.		Number of cows yielding						
		Below 3,000 lbs.	3,000 to 4,000 lbs.	4,000 to 5,000 lbs.	5,000 to 6,000 lbs.	6,000 to 7,000 lbs.	7,000 to 8,000 lbs.	8,000 lbs. and over.
1 Montgomery Dairy Farm	..	32	41	6	3	5	0	0
2. Jehangirabad Cattle Farm	..	48	62	95	37	11	0	2
3 Allahdad's Farms Jahanian	..	17	27	45	44	20	10	3

TABLE 31.—*Typical yields of improved cattle (average values).*

—	Purchased.	Farm bred	—
Kangayam	1,493	1,615	Hosur, Madras.
Kankrej	932	1,936	Charodi, Bombay.
Gir	2,052	2,500	Charodi, Bombay.
Ongole	2,674	3,520	Chintaladevi, Madras
Hariana	2,379	3,634	Karnal, Punjab
Tharparker	2,294	3,791	Karnal, Punjab.
Sindhi	3,572	4,137	Hosur, Madras
Sahiwal .. .	2,800	7,000	Ferozepur, Punjab

TABLE 32.—*Comparison of number of cows and she buffaloes at successive five-year periods*

—	Population in thousands		Percentage changes *	
	Cows	She Buffaloes	Cows.	Buffaloes
1915-16 .	37,697	13 629	100	100
1920 21 .	37 083	13 312	98	98
1925 26 .	37,901	14,205	101	104
1930 31 .	37,994	14 707	102	108
1934-35	38,696	15 438	103	113

* 1915 16 taken as 100

TABLE 29.—*Progressive increase in milk yield shown by herds at Lyallpur, Karnal, Pusa and Ferozepore from the date of their establishment.*

	Average daily yield (lbs.)				
—	Lyallpur Agricultural College Dairy.	Karnal.	Pusa.	Ferozepore.	Overall.*
First year	[illegible]	[illegible]	[illegible]	11·5	4·6
Second year	[illegible]	7·1	[illegible]	11·6	5·9
Third year	[illegible]	[illegible]	[illegible]	12·0	8·6
Fourth year	[illegible]	[illegible]	6·6	12·9	9·2
Fifth year	[illegible]	10·2	[illegible]	12·6	9·8
Sixth year	[illegible]	[illegible]	[illegible]	14·8	10·6
Seventh year	9·31	9·9	7·4	14·7	11·3
Eight year	7·271†	12·2	8·2	15·0	11·1
Ninth year	9·10	[illegible]	[illegible]	16·2	11·9
Tenth year	[illegible]	13·2	9·4	16·4	11·7
Eleventh year	9·03	13·2	10·8	17·4	12·5
Twelfth year	[illegible]	14·1	12·0	16·4	12·1
Thirteenth year	11·28	..	12·3	15·3	9·9
Fourteenth year	10·73	..	11·7	18·0	12·5
Fifteenth year	11·97	..	12·7	17·0	12·5
Sixteenth year	11·40	..	14·3	15·4	12·0
Seventeenth year	11·67	..	12·4	16·9	12·9
Eighteenth year	12·82	..	13·0	17·7	12·8
Nineteenth year	11·43	..	13·6	20·3	17·0
Twentieth year	15·05	..	18·5	22·6	16·8
Twenty-first year ..	16·54	..	..	18·3	13·7
Twenty-second year ..	17·15	..	..	16·5	11·1

NOTE.—Karnal herd (Hariana and Tharparkar) was started in 1923 and Pusa and Ferozepore (Sahiwal) in about 1912, and the Lyallpur herd (Sahiwals) in 1914.

* These are overall averages, *i.e.*, averages computed over milking and dry stock, whereas those shown in other columns are milking averages. Further the progressive increase of the Ferozepore herd is often masked by the influx of fresh cows which are purchased in the market for meeting the requirements of trade. These are not separately shown in administration reports.

† Fall due to severe attack of Foot-and-mouth disease.

TABLE 30.—*Distribution of milk yields in three Sahiwal herds.*

Name of farm.	Number of cows yielding.						
	Below 3,000 lbs.	3,000 to 4,000 lbs.	4,000 to 5,000 lbs.	5,000 to 6,000 lbs.	6,000 to 7,000 lbs.	7,000 to 8,000 lbs.	8,000 lbs. and over.
1. Montgomery Dairy Farm ..	32	41	6	3	5	0	0
2. Jehangirabad Cattle Farm ..	48	82	95	37	11	0	2
3. *Allahdad's* Farms Jahanian ..	17	27	45	44	20	10	3

TABLE 31.—*Typical yields of improved cattle (average values).*

—	Purchased.	Farm-bred.	—
Kangayam	1,493	1,616	Hosur, Madras.
Kankrej	932	1,936	Charodi, Bombay.
Gir	2,052	2,600	Charodi, Bombay.
Ongole	2,674	3,526	Chintaladevi, Madras.
Hariana	2,379	3,634	Karnal, Punjab.
Tharparker	2,294	3,791	Karnal, Punjab.
Scindi	3,572	4,137	Hosur, Madras.
Sahiwal	2,800	7,000	Ferozepur, Punjab.

TABLE 32.—*Comparison of number of cows and she-buffaloes at successive five-year periods.*

—	Population in thousands.		Percentage changes.*	
	Cows.	She-Buffaloes.	Cows.	Buffaloes.
1915-16	37,697	13,629	100	100
1920-21	37,093	13,312	98	98
1925-26	37,901	14,205	101	104
1930-31	37,994	14,707	102	[illegible]
1934-35	[illegible]	[illegible]	103	113

* 1915-16 taken as 100.

…ce of cows and buffaloes in relation to milk production.

Province.	Bovine population.		Average lactation yields (lb.).		Total milk production* (in thousand maunds).		Proportion of milk contributed by buffaloes.
	Breeding cows, *i.e.*, cows over 3 years old kept for breeding or milk production.	Breeding buffaloes, *i. e.*, buffaloes over 3 years old kept for breeding or milk production.	Cows.	Buffaloes.	Cows.	Buffaloes.	
Assam	1,305,188	112,781	170	430	2,771	628	18·4
Bengal	7,673,067	256,669	420	960	40,283	3,080	7·6
Bihar and Orissa	5,792,528	1,625,792	440	1,770	31,913	37,166	53·9
Bombay	1,796,896	1,153,869	500	885	11,135	12,035	51·9
Central Provinces	3,216,893	830,084	500	700	19,745	7,221	26·8
Madras	4,280,661	2,395,870	430	775	23,112	23,175	50·1
North-West Frontier Province	206,974	137,648	800	1,200	2,069	2,164	51·2
Punjab	2,549,778	2,873,692	1,400	2,160	44,745	78,040	63·6
Sind	761,107	339,573	1,000	1,500	9,513	6,350	40·0
United Provinces	5,726,249	4,060,877	800	1,000	57,262	50,760	46·9

* Excluding goat's milk. It should be noted that in calculating total milk production allowance has been made for the fact that many of the animals in the first two columns will not be in milk.

TABLE 34.—*Total available feeding stuffs.*

—	Available quantity (1,000 tons).	Calculated Nutrients.				Nutritive Ratio.
		Digestible crude protein (1,000 tons).	Digestible carbohydrates (1,000 tons).	Digestible fats (1,000 tons).	Total digestible nutrients (1,000 tons).	
[illegible]	111,000	1,010	34,550	383	36,480	1 : 36·0
[illegible]	100,000	1,000	10,000	250	11,562	1 : 10·6
[illegible]	[illegible]	[illegible]	375	150	1,163	1 : 1·6
[illegible]	[illegible]	[illegible]	690	367	1,818	1 : 5·1
Total	[illegible]	2,700	45,615	1,150	51,013	1 : 17·5

TABLE 35.—*Acreage under fodder crops.*

Year.	Area (million acres).	Year.	Area (million acres).
1901	2·9	1920	8·1
1905	3·9	1925	8·9
1910	4·8	1930	9·3
1915	7·1	1935	10·2

TABLE 36.—*Distribution of yields of certain fodder crops.*

Yield (maunds per acre).	Percentage giving yields within limits shown in first column.					
	Juar.	Maize.	Oats.	Berseem.	Lucerne.	Grasses.
0—199 ..	37	61	35	22	26	17
200—399 ..	52	36	56	35	40	24
400—599 ..	7	3	9	19	23	36
600—799 ..	4	0	0	9	4	5
800—999 ..	0	0	0	9	7	6
over 1,000 ..	0	0	0	6	0	12
Total ..	100	100	100	100	100	100

TABLE 37.—*Distribution of costs of certain fodder crops.*

Cost (per maund).	Percentage giving costs within limits shown in first column.					
	Juar.	Maize.	Oats.	Berseem.	Lucerne.	Grasses.
As. p. As. p.						
Below 1–11 ..	52	18	22	50	20	40
2–0 to 3–11 ..	34	40	43	18	37	28
4–0 to 5–11 ..	8	18	14	16	7	17
6–0 to 7–11 ..	2	18	0	3	6	7
8–0 to 9–11 ..	0	3	0	6	13	2
10–0 to 11–11 ..	0	0	4	3	3	0
Over 12–0 ..	4	3	17	3	13	3
Total ..	100	100	100	100	100	100

TABLE 38.—*Density of cows and she-buffaloes and of human population in various districts in India.*

Province.	District.	Per square mile.		
		Number of cows.	Number of buffaloes.	Human population.
United Provinces ..	Allahabad	64	41	524
	Etawah	48	55	441
	Agra	39	63	567
	Muttra	45	63	461
	Etah	42	81	501
	Aligarh	24	83	602
	Bareilly	45	49	679
Punjab	Hissar	23	17	172
	Rohtak	35	37	326
	Karnal	45	49	273
	Lahore	26	55	514
	Lyallpur	22	62	357
Bihar	Purnea	96	22	440
	Bhagalpur	85	28	529
	Darbhanga	96	41	916
	Muzaffarpur	80	44	969
	Champaran	90	34	[illegible]
	Saran	67	52	927
Bombay	Ahmedabad	19	25	239
	Kaira (Anand)	16	79	[illegible]
South India ..	Bangalore	57	18	311
	Coimbatore	34	13	249

TABLE 38(a).—*Density of cows and she-buffaloes and of human population in British Provinces.*

Province.	Per square mile.		
	Number of cows.	Number of buffaloes.	Human population.
United Provinces	60·1	42·6	508·2
Punjab	26·3	29·7	243·7
Bihar and Orissa	59·9	18·7	453·6
Madras	30·0	16·8	328·5
Bombay	23·2	14·9	232·9
North-West Frontier Province ..	15·3	10·1	179·3
Central Province and Berar ..	32·1	8·3	155·2
Sind	16·4	7·3	83·8
Bengal	91·5	3·4	646·4
Assam	23·7	2·0	156·7

TABLE 39.—*Experimental, district and demonstration farms.*

Province or State.	Experimental Farms.	District and Demonstration Farms.	Cattle-breeding Farms.
Madras	..	..	2
Bombay	5	10	5
Sind	1	6	..
Bengal	3	22	1
United Provinces	4	18	4
Punjab	8	14	1
Bihar and Orissa	5	18	2
Central Provinces	3	2	9
Assam	3	..	4
North-West Frontier Province ..	2	3	..
Indian States	22	16	11
Total ..	56	109	39

TABLE 40.—*Acreage of farms and number of live-stock at provincial agricultural and veterinary colleges.*

—	Provincial Agricultural Colleges.						Provincial Veterinary Colleges.				
	Allahabad.	Cawnpore.	Coimbatore.	Lyallpur.	Nagpur.	Poona.	Bombay.	Lahore.	Madras.	Patna.	Calcutta.
Total area of farm (acres) ..	500	39	270	*30	275	355	None	None	None	650	None
Total head of bovines ..	239	74	131	74	104	204	None	None	None	634	20
Whether oxen are pure-bred or cross-bred.	Both	Pure-bred.	Cross-bred.	Pure-bred.	Cross-bred.	Pure-bred	..	..	..	Pure-bred.	Cross-bred.
Whether buffaloes are kept ..	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes
Total milk produced (lb. per day).	875†	324	325	400†	400	1,000	None	None	None	1,177	16

* Refers only to the Dairy Farm.
†Additional milk is purchased for use in the College Dairy.

TABLE 41.—*The number of agricultural and veterinary officers in British provinces in 1936-37.*

Provinces.	Agriculture.		Veterinary.	
	Gazetted officers.	Non-gazetted officers.	Gazetted officers.	Non-gazetted officers.
Central Provinces	25	166	7	163
Bombay	38	208	9	143
Madras	59	464	23	274
Punjab	69	236	36	406
United Provinces	44	274	4	226
Bengal	26	188	13	174
Bihar	18	113	11	139
Orissa	14	14	2	28
Assam	9	54	2	60
North-West Frontier Province	5	18	2	33
Total ..	307	1,735	109	1,646

TABLE 42 —*Expenditure on live-stock improvement and veterinary services.*

—	Agricultural Department		Proportion allotted for live-stock improvement	Veterinary Department Total budget	Total for veterinary department and live stock improvement.	Total budget for both departments	Proportion utilised for animal husbandry work *
	Total budget.	Allotted for live stock improvement					
	Rs	Rs		Rs	Rs	Rs	
Madras	18,47,000	1,15,800	6 2%	9,63,000	10,78,800	28,10,000	38 3%
Bombay	12,29,000	91,000	7 4%	3,78,000	4,69,000	16,07,000	29 2%
Bengal	9 95,000	54,367	5 4%	4,82,000	5,36,367	14,77,000	36 3%
Punjab	25,96,500	53,836	2 1%	12,91,000†	13,44,836	38,87,500	34 6%
United Provinces	23,62 300	1,20,738	5 1%	4,36,000	5,56,738	27,98,300	19 9%
Central Provinces	9,00,000	95,020	10 5%	3,86,000	4,81,020	12,86,000	37 3%
Bihar	6,92 617	43,218	6 2%	5,21,574†	5,64,792	12,14,191	46 4%
Assam	4,86,881	1,15,386	23 7%	1,41,203	2,56,589	6,28,084	40 8%
North west Frontier Province	2,15 000		.	1,28,700†	1,28,700	3,43,700	37 2%
Total	1,13,24,298	6,89,365	6 1%	47,27,477	54,16,842	1,60,51,775	33 7%

* i e, expenditure on veterinary departments *plus* expenditure on live stock improvement allotted by agricultural departments

† The amounts allotted for live stock improvement by these veterinary departments are as follows — Punjab, Rs 2,32,900, ; Bihar, Rs 53,151. North West Frontier Province, Rs 20,200

TABLE 43.—*Number of cattle per veterinary assistant and expenditure per head of cattle in British provinces.*

Provinces.	Number of cattle per veterinary assistant.	Expenditure on veterinary services and live-stock improvement per head of cattle (pies).
North-West Frontier Province	29,500	23·8
Punjab	36,000	16·3
Bombay	65,500	9·1
Central Provinces	81,500	6·7
Madras	82,500	8·4
Assam	96,500	8·2
Bengal	135,000	4·1
United Provinces	141,000	3·3
Bihar	142,000	5·1

TABLE 44.—*Amounts spent annually on the* gowshalas *and* pinjrapoles *at seven typical centres.*

Town.	Total population.	Amount annually spent on *pinjrapoles and gowshalas.*	Per head annual donation.		
		Rs.	Rs.	a.	p.
Karachi	263,565	1,48,337	0	9	0
Cawnpore	243,755	95,319	0	6	3
Bombay	1,161,383	3,09,594	0	4	3
Delhi	447,442	1,11,919	0	4	0
Muttra	60,590	4,200	0	1	1
Agra	229,764	14,968	0	1	0
Allahabad	183,914	3,000	0	0	3

TABLE 45 —*Details of the milk supplies of certain cities.*

—	Bombay	Madras	Lahore	Hyderabad	Lucknow	Bangalore
Population	1 161 383	692,336	400,075	304,799	251,097	134,113
Number of cattle in—						
cattle stables	15 679	11,863	7,531	5,958	2,238	1,047
private milch cattle keepers' premises	2,570	1,485	3,098	1,351	584	281
Percentage of milk produced —						
(a) within the municipality	66 7	82 0	34 0	80 6	77 3	38 2
(b) within 5 miles of the municipality	33 3 (b and c together)	7 3	28 0	14 1	8 7	42 2
(c) more than 5 miles outside the municipality		10 7	38 0	5 3	14 0	19 6
Number of milk shops	971	56	593	255	289	24
Number of milk vendors	1 483	1,442	275	54	152	225

TABLE 46.—*Relative demand for milk each month.*

Month.	Hill Station A.	Hill Station B.
January	100	127
February	130	100
March	260	146
April	492	181
May	673	378
June	650	446
July	547	490
August	544	500
September	597	527
October	647	357
November	318	179
December	163	160